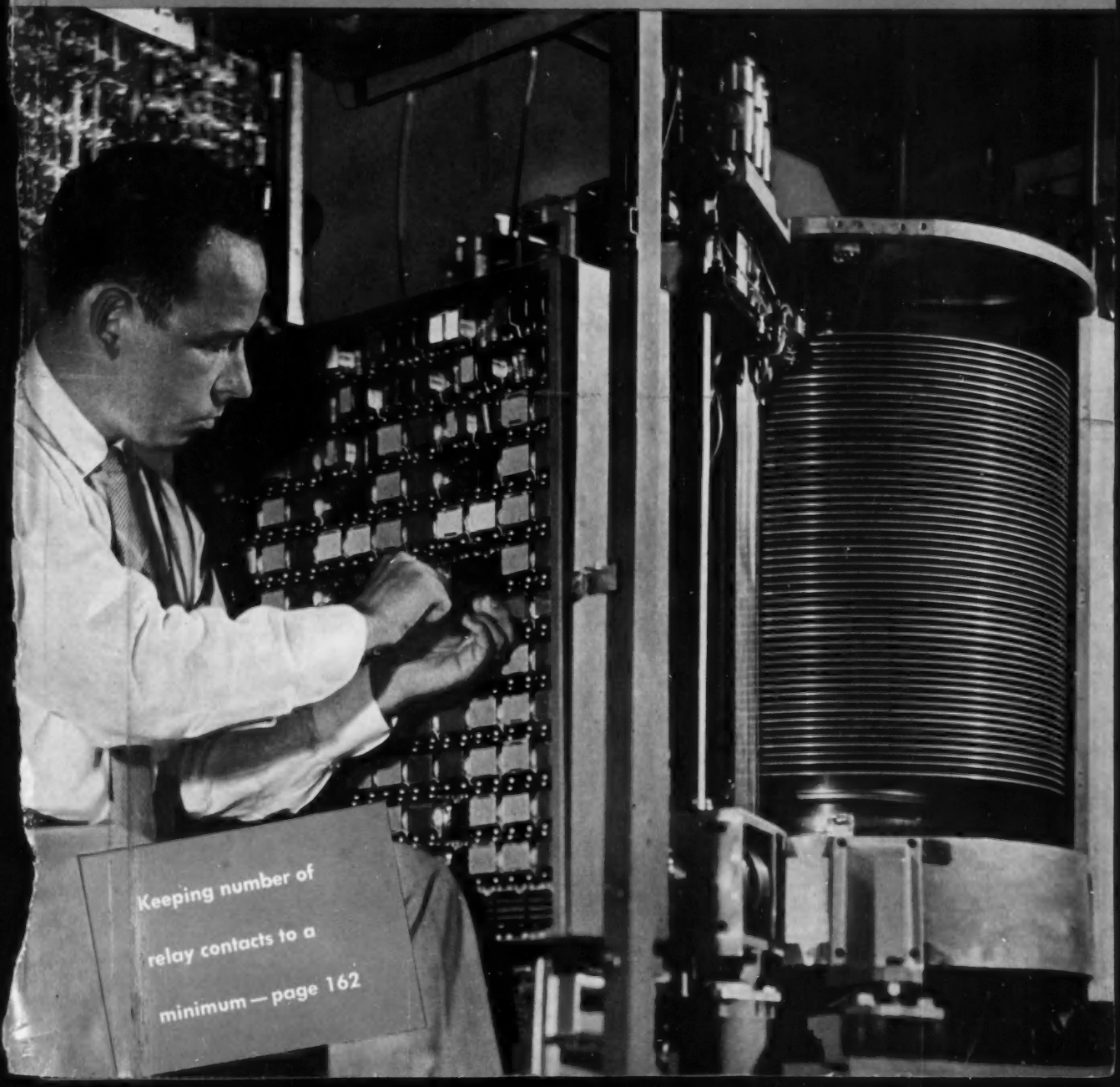
NOVEMBER 1956

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING
FIVE DOLLARS A YEAR

Tough Plastics
properties compared
Precision Gearing
Random Vibration
Creep of Coil Springs



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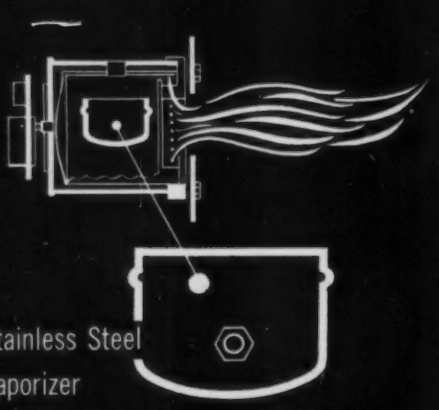

Stainless Steel
Vaporizer
Cup

Stainless Steel replaces cast iron in burner cup...

saves 60¢ a part, cuts weight 90%

About a year ago a manufacturer of oil burners changed specifications from cast iron to stainless steel for this vaporizer cup.

It saves him $0.605 on each part—35 per cent on materials and labor alone—and practically eliminates service failures.

By welding a stainless steel spud (machined from ¾" hexagon-shaped bar) to the cup (drawn from .028 Type 304 stainless strip) the burner producer gets a more dependable part at much less cost.

The vaporizers formerly used not only created service problems but took a high toll in tool grinding and replacement costs. Switching to stainless ended this headache too.

Big cost savings . . .

OLD CUP
(Cast Iron—1.2 to 1.4% chromium)

Cost of casting	$1.090
Machining (grinding, boring, drilling, tapping	0.274
Total	$1.364
(Material and Labor)	

NEW CUP AND SPUD
(Type 304 Stainless Steel)

Cup material	$0.330
Spud material	0.100
Drawing	0.119
Welding	0.200
Punching, beading cup and Machining spud	0.132
Total	$0.881
(Material and Labor)	

Material and Labor Saving	$0.483 (35%)
Overhead Saving	0.122
Total Saving, per cup	$0.605

Weight cut 90%

Weight went down with costs. The cast iron cup weighed 5 pounds; the stainless cup weighs only ½-pound. What's more, the stainless cups are virtually immune to "burn-out."

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Armco's wide variety of stainless steels makes it possible for you to select the one right grade for your products. We produce all standard and many special grades in sheets, strip, plates, bars and wire. Get more information about Armco Stainless Steels by calling the Armco Sales Office near you, or writing us at the address below.

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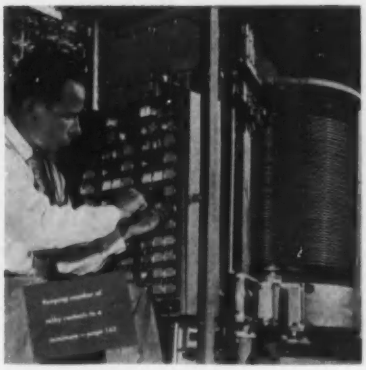

THIS MONTH'S COVER

An engineer inserts a relay into the gate of International Business Machines Corporation's new random access memory unit. The circuitry for this device, a component of the IBM 650 RAMAC data processing system, was designed in the company's Endicott Product Development Laboratory. Switching circuit design methods are described in an article beginning on page 162.

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Interesting

to Note . . . .

Satellites and Gondolas

It was not until almost 100 years after Sir Humphry Davy first produced magnesium by electrolysis that this metal became to be produced commercially. Yet, once it got started, the amount produced increased at an extremely rapid rate from 400 short tons in 1932 to 184,000 tons for the year 1943.

Humphry Davy's career was varied and his progress was dramatic. At the age of 21 he discovered the effects of nitrous oxide and thereby introduced "laughing gas." At 23, Davy became acquainted with Count Rumford, who made him assistant to the lecturer of chemistry, and only ten weeks later a lecturer, and a year later, professor at the Royal Institute. In 1813, five years after he discovered magnesium, the knighted Sir Humphry Davy had discovered fluorine, and in 1815 he invented the Miner's Safety Lamp at the behest of the coal owners of Newcastle.

Magnesium, an underrated material, received a sizeable publicity boost recently when it was announced that the shell of the Earth Satellite will be made of the metal. However, this is not the first time that magnesium has been used to set altitude records. Back in November 1935, the "Explorer II," a 3,700,000 cu ft balloon of the National Geophysical Society—Army Air Corps Stratosphere Expedition set a new world record altitude mark of 72,395 ft above sea level. The largest free balloon ever built, it carried a 9 ft, 600 lb air-tight gondola made of $\frac{3}{16}$ in. magnesium alloy. Besides two observers, the gondola carried the largest cargo of scientific instruments ever taken aloft.

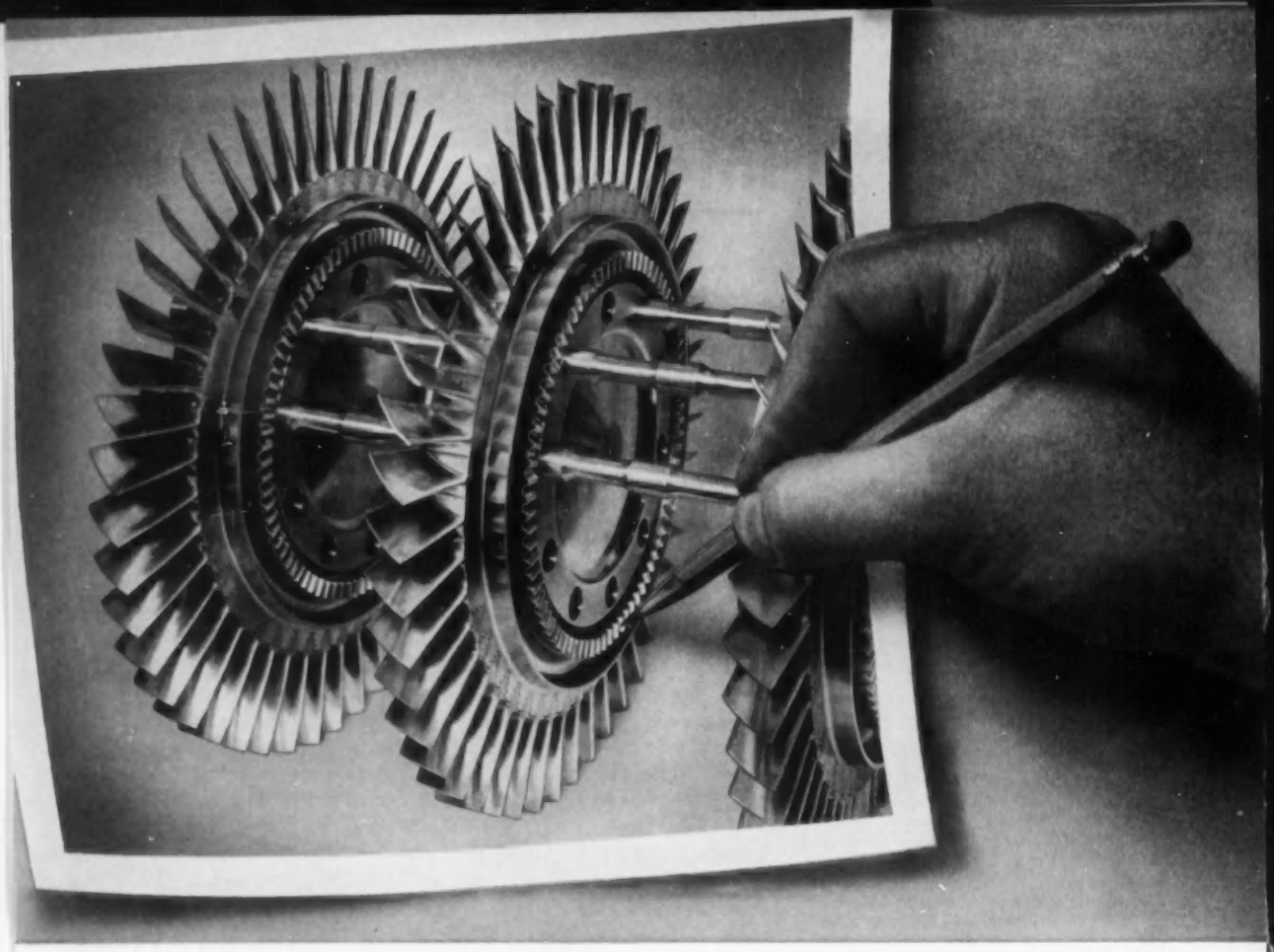
Many things were revealed by the flight of the Explorer II. Cosmic rays were found to increase greatly in number as the balloon rose above the earth, with roughly 50 times as many at 72,000 ft than at sea level. Electrical conductivity was found to increase steadily with altitude, and was 100 times greater at 72,000 ft than at sea level. More up to date information on a magnesium-thorium alloy can be found in an article beginning on page 200.

Quiet!!

The *Encyclopedia Brittanica* devotes thirty pages to the subject of "sound," but at the outset states that there is no definition for that form of sound which is called noise. However, "Noise is on every payroll and costs American business around $4 billion per year," according to Sam L. Hooper, of Remington Rand and past president of the National Noise Abatement Council. Studies have shown a strong relationship between noise and plant turnover, production, accuracy and health. The Aetna Insurance Co., Hartford, Conn., has shown that a reduction in plant noise has brought general efficiency up 9.2 per cent, decreased typing errors 29 per cent, decreased machine operators' errors 52 percent and reduced employee turnover 47 per cent. Aetna has concluded that by bringing down noise levels in a plant or office a net savings of $58 per employee will be achieved.

Industrial compensation agencies throughout the country have been confronted with an increasing number of claims for loss of hearing due to industrial noise. In 1947, 232 suits were filed against the Beth-

(*Continued on page 7*)



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They have done so for scores of manufacturers, by reducing machining time, by saving time in assembly and by permitting more compact design.

CURVIC Couplings are extremely accurate toothed connections which combine the functions of driving, centering and alignment.

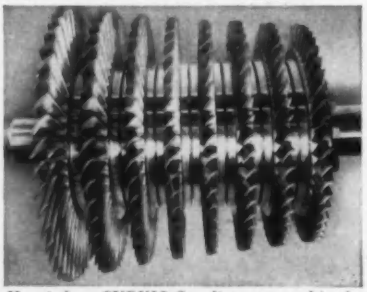
With CURVIC Couplings, complex machine parts can be made in several smaller units and then bolted or otherwise fastened together. Experience has proved that fabrication of many large parts in smaller units has reduced the time spent in machining, simplified final assembly, and reduced over-all manufacturing costs.

And there is no sacrifice of precision—in fact, CURVIC Couplings are so accurate that tolerances in the finished assembly can be held closer than when the part is made by any other means.

CURVIC Couplings are used in such applications as heavy-duty gas turbine rotors like the one shown above, jet engines, crankshafts and camshafts.

In addition to fixed or permanent connections, CURVIC Couplings can be produced in semiuniversal, and in releasing clutch types.

All types of CURVIC Couplings are produced rapidly, economically, and with high precision, on Gleason Cutting and Grinding Machines. If you would like to know more about CURVIC Coupling design or manufacture, the Gleason Works will be glad to consult with you, and to make recommendations about your specific applications. Write for our booklet.



Here is how CURVIC Couplings are used in the production of an 8-stage heavy-duty gas turbine rotor, holding it in perfect alignment under the severe stresses encountered at high speed.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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Interesting to Note . . . .

lehem Steel Co. by workers claiming $5 million damages on hearing losses allegedly suffered from high noise levels at their jobs. It has furthermore been estimated that litigations amounting to from three million to two billion dollars are pending before Workmen's Compensation Boards. These figures become more staggering when one considers a hypothetical case of a drop forge shop in New York State employing 500 men. Since this industry is one of the nation's noisiest, all employees could file claims for loss in hearing which could bring them $36.00 per week, through Workmen's Compensation benefits. Were all claims allowed, a loss of close to a million dollars per year would result, which would seriously effect an employer and eventually the product consumer. You might be either one of these, so the article on page 143 should be of interest.

Ut Tensio Sic Vis

Less than 300 years ago there was no spring art, nor an understanding of the elastic behavior of metals. The first-published statement of the law of elasticity was made by Robert Hooke in a pamphlet he had printed in 1678.

In his treatise, Hooke went on to define his theory, using the Latin phrase "Ut Tensio Sic Vis," literally translated "As the deformation, so the force." Hooke paraphrased it thus, "The power of any spring is in the same proportion as the tension thereof: that is, if one power will stretch or bend it one space, two (powers) will bend it two, and three will bend it three, and so forward.'

But it did not take long to discover that "Hooke's Law" had some complex functions. Going over some experiments with watch hairsprings, Hooke noted that room temperature seemed to affect the time-keeping characteristics. It was not until recently that we found a more complete understanding of the true complexity of elastic behavior—that the deflection of a spring is also influenced by: stress level, the direction of load change, time under load, rate of load application, past history of loading, as well as ambient temperature. The problem of elasticity that faced Hooke in the 17th century are present today. On page 186, an article appears dealing with high temperature creep of coil springs.

The $10,000 Question

In 1868, the shortage of ivory for making billiard balls prompted a manufacturer to offer a prize of $10,000 to anyone who could furnish a material which could be used as a substitute. Numerous chemists attempted to solve the problem but were not successful. It was an Albany printer with a flair for inventing named John Wesley Hyatt, (Ancestor of General Motors Corp. Hyatt Bearing Div.), who won the award. He tried mixing cellulose nitrate, made from cotton linters and nitric acid, with camphor. The result was "celluloid." It was forty years later in 1908, that a Belgian chemist named Dr. Leo H. Baekeland, (after whom Bakelite was named) tried to produce a grade of shellac better than the then existing natural resin produced by insects in Asia and southern India. Using phenol, formaldehyde, intense heat and a catalyst, he produced a compound which could be molded under heat and pressure. Continuing his experiments, he found that when other materials, now known as "fillers," were added to the resinous mixture, materials with widely varying properties could be produced. Thus, began the production of "phenolics."

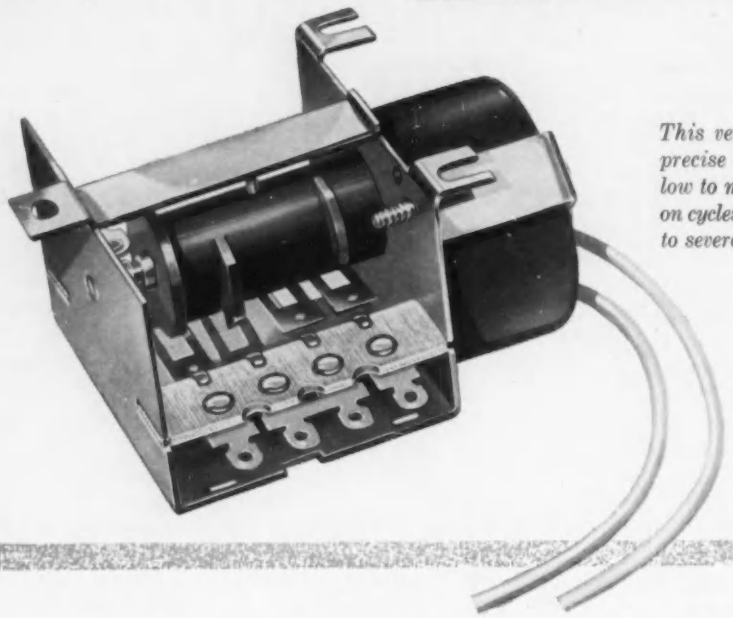
The results of the discoveries of Hyatt and Baekeland had little impact upon American industry. Then, like a rocket, the synthetic resin field explored skyward. The Society of Plastics Industry has estimated the 1955 production of dozens of types of synthetic resins to be almost 3.6 billion lb; a 500 per cent increase within 15 years. An article on choosing rigid thermoplastics begins on page 167.

Death, Delay, and Diecasting

In the bay of Boston during October of 1953 an explosion occurred aboard a Navy aircraft carrier, the U.S.S. Leyte, that took 36 lives and injured dozens. Vice-Admiral John J. Ballentine, commander of the U. S. Air Force, Atlantic Fleet, commented after a personal survey of the blasted and burned forward end of the carrier, "It is obvious to me that the hydraulic fluid used in the catapult was somehow voided and converted into an explosive mixture." Less than a year later on May 27, 1954, a similar explosion of vaporized hydraulic oil took place in the catapult room of the carrier U.S.S. Bennington, claiming more lives and injuring others. The Navy has now converted its catapults to a water base fire resistant hydraulic fluid, thus ending a dangerous condition in aircraft carrier launching devices. Industry also has paid the price for failure to adopt fire resisting fluids where feasible. A California diecaster continued delaying installation of a fire resistant system in his plant, claiming that his production requirements were too great to shut down his machinery. Evenually a hydraulic line broke under pressure, spraying the area with flammable oil which ignited and set fire to the building. Fortunately, no fatalities resulted, but his production ceased while the shop underwent repairs. Some insurance companies now require the installation of sprinkler systems in diecasting plants using flammable fluids.

How you can efficiently change to fire resistent fluids is outlined on page 194.

MALLORY



This versatile switch provides precise control of numerous low to medium power circuits, on cycles ranging from 1 second to several hours or longer.

Precision switching on long or short cycles... with Versatile New Mallory Timer

THIS is one of the most versatile timer switches that Mallory specialists have designed. Originally conceived as a short-cycle timer for automatic vending machines, it is now available in many modifications that fit the needs of short to long cycles in numerous low to medium power uses—in appliances, and scores of other products powered by fractional horsepower motors.

PRECISION TIMING. The combination of a constant speed permanent magnet motor and contact action by sharp cam rise gives highly accurate timing. On a 7½-second cycle, for instance, accuracy of ±20 milliseconds is guaranteed.

MOTOR RESET eliminates uncertainty and inflexibility of mechanical spring flyback at end of cycle.

MANY VARIATIONS of the basic design are readily available at economical cost. Numerous circuits can be handled. For example, one version of the timer controls five circuits, one of which is motor reset . . . or 6 circuits if the full potential accuracy of the timer is not required. The precision-timed portion of the cycle can be made adjustable by a variable cam. Tooling is also available for direct adjustment of this part of the cycle, by means of a screwdriver vernier accessible through the end plate of the housing. Total cycle time can be anywhere from 1 second to several hours or more.

HIGH DEPENDABILITY. There are few moving parts. Silver contacts, Underwriters' Laboratories approved, have long life beryllium copper springs.

Standard a-c ratings are 10 amperes, 125 volts and 5 amperes, 250 volts. Other ratings are possible.

For complete data, and for a consultation by Mallory specialists in timer switch applications, write or call us today.

Expect more... Get more from

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Tuning Devices • Vibrators
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Developments

To Watch

GETTING FORGING STRENGTH IN A CASTING. . . .

. . . . is an economic interest of the Air Force who would like to cut some of its aircraft costs. In a project now under way at the Armour Research Foundation of the Illinois Institute of Technology, Chicago 16, Ill., the process is to make a casting of aluminum or magnesium essentially to shape, with the final shape produced by press forging. The idea is to find out how much forging is needed to get forging strength. A small amount of forging, 10 to 20 per cent deformation, produces a good increase in yield strength. With aluminum, work has been done only with the casting alloy 356 (7 per cent silicon, 0.3 per cent magnesium), and the results are not too favorable. A 30-40 per cent increase in yield strength resulted from press forging, but its elongation decreased from 3½ per cent to ½ per cent, making the part too brittle.

With magnesium, AZ 92 (9 per cent aluminum, 2 per cent zinc), press forging gave a 30-40 per cent increase in yield strength and the elongation remained the same. In both cases the parts were solution heat treated, press forged, and aged. If the last two processess are reversed, the yield strength increase is only about 25 per cent. Magnesium was press forged at its lowest possible temperature, 400 F. Aluminum was worked at room temperature.

From the standpoint of cost, it was found that press forging is slightly more than casting, but much less than forging. Another series of tests will be made using a forging alloy for the casting, prior to press forging. Or, in the case of aluminum's elongation drawback, the casting alloy might be altered.

A MULTI-COLOR PRINTING AUTOMAT. . . .

. . . . designed by the Adrema-Werke, Berlin, Germany, is reported to be able to simultaneously: (1) reproduce a typewritten text through a color typewriter ribbon; (2) address this text with a one-piece plate with sight strip, cams, and riders; (3) and carry out polychrome book printing from zinc etchings or rubber stereotype plates. The device, model AVA, works on the principle of book printing rotation, and can be used either as a combination machine for these operations, or for different jobs in those fields. A new type of rubber block permits offset work with the AVA, with the only difference that the colors of AVA prints have a greater luminosity. It was designed primarily for small printing firms and advertising departments. Printing capacity is about 4000 prints per hr, with the largest printing size 24 x 30 cm. It can process any paper between 20 g airmail and 300 g carton. Also used on the machine is a selection aggregate, which when coupled with a register aggregate, makes statistical surveys concurrently with the printing work.

RUGGEDIZED, WATERPROOF TEST SETS. . . .

. . . . are being dropped three feet onto concrete and submerged in water, and still function at the Naval Ordnance Lab., White Oak, Silver Spring, Md. New concepts in design and engineering, plus the use of well known procedures in standardization are said to be responsible for this series of test sets that are easier to operate, manufacture, and service than earlier models. NOL found that precision test equipment does not have to be fragile. In the new test sets, the careful selection of components, the use of standard structural design techniques,

(Continued on page 10)

and the use of standard fiber glass transit cases were employed. The test sets will withstand normal use and transportation, and failures because of moisture and dust have been eliminated. The sets are built directly into, and are normally used in the fiber glass cases. The case is so rugged that additional packaging during shipment is not needed. Conventional gasketing and O-ring sealing is used, plus a quantity of desiccant to keep the air dry inside the set. No component is shock mounted. The major conclusion drawn from this project is that test sets cannot be designed as afterthoughts, but must be considered as an important part of the weapon system.

DECORATIVE FINISHES TO ALUMINUM SHEET. . . .

. . . . and extruded shapes are possible with Spangle-Sheet, a new metal finishing procedure devised by the Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa. The finish presents many reflecting facets, imitating a continually changing surface pattern, and has been applied in color and natural finish to plain and patterned rolled sheet and extruded shapes. The finish is the result of inducing the formation of abnormally large grains in a special aluminum alloy. Individual grains are then made to stand out in relief by an acid etch. Spangle-Sheet is still in the experimental stage and is not yet available commercially.

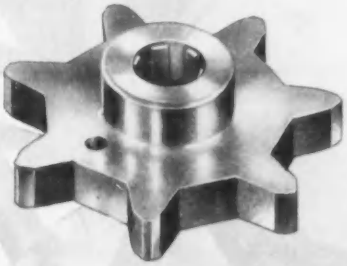
COMBINING POWDER METALLURGY PROCEDURES WITH INVESTMENT CASTING. . . .

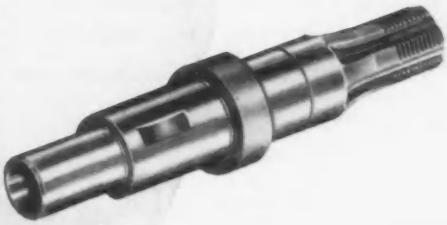
. . . . a new process called Sintercasting has produced a cement-type titanium carbide with a low specific gravity, high strength, and high heat conductivity for use as turbine blades, guide vanes, and other gas turbine components. The process starts with a skeleton body pressed and sintered from a high melting point material such as titanium carbide, which is the exact copy of the finished product in shape, dimensional tolerance and finish. Then, using the investment casting process, these titanium carbide skeletons are interstitially cast with high nickel and cobalt alloys for good wear resistance and high temperature operation (1800 F). The result is a titanium carbide cermet with impact resistance, in conjunction with stress rupture properties which are above those of present blading alloys. Machinable in the annealed condition, it can be hardened by conventional quenching methods after fabrication and can be arc welded without distortion. Known as Ferro-Ti C, it was developed by the Sintercast Corp. of America, 134 Woodworth Ave., Yonkers 2, N. Y. The technique also permits the production of composite structures containing binder alloy-rich leading and trailing edges for added high strength. Rockwell C hardness of Ferro-Ti C is 63-73; of Tool Steel 64-67; of Cemented Tungsten Carbide 65-80; of cast Cobalt-base alloy 30-65.

A LIQUID LEVEL SWITCH WITH NO MOVING PARTS. . . .

. . . . is a thermal instrument operating on a difference in heat transfer between the sensitive element and the liquid in the vessel, or the sensitive element and the vapor. Used particularly for the indication and control of liquid level in tanks, boilers, sterilizers, and other types of industrial vessels, the switch is capable of switching loads up to 5 amp at 250 v a-c without subsidiary amplifiers or relays. It requires no maintenance, and can be used where the interior of the vessel being controlled is not readily accessible for cleaning or repairs. Changes of level on the order of ½ in. is sufficient to operate the switch. The operating mechanism

(*Continued on page 13*)





YOU'LL FIND G.S. GEARING IN TOP QUALITY PRODUCTS LIKE THESE . . .

Adding Machines • Aircraft Carburetors & Fuel Metering Systems • Aircraft Instruments and Radios • Automatic Musical Instruments • Business Machines • Chain Saws • Check Signing & Protecting Machines • Clippers for Barbers, Animal Shearing & Hedge Trimming • Cloth Cutting Machines • Coin Changers & Counters • Communication Equipment • Electric Fans • Electric Motors • Floor Polishers, Sanders, Scrubbers, Sweepers • Food & Drink Mixers, Blenders • Home Appliances • Lawn Sprinklers • Machine Tools • Meat Tenderizers, Grinders, Slicers • Military Equipment • Motion Picture Cameras & Projectors • Outboard Motors • Pneumatic Production Tools • Portable Electric Tools • Radio & Radar Tuning Assemblies • Radio Anti-backlash Gears • Record Changers • Sewing Machines • Steel Strap Stretchers • Step Switches • Tapping, Drilling & Threading Equipment • Telephone Dials • Television Sets • Thermostatic Controls • Typewriters • Vending Machines • Washing Machines.

GEAR Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

RUGGED MERCURY CHAIN SAW ASSURES UNFAILING SERVICE WITH G. S. GEARING

Rugged dependability is traditional of all MERCURY engines manufactured by the KIEKHAEFER CORPORATION. Their new Chain Saw, *with Gearing by G.S.*, is designed and built to stand up under the hardest kind of service. ★ More and more manufacturers of TOP QUALITY mechanisms are turning to G.S. for Small Gearing. For, here at "Headquarters", they get *extreme uniform accuracy!* Assembly lines keep rolling. Rejects vanish. Costs come down. Customer satisfaction increases as products run smoother, quieter, longer. Start now enjoying all the superior advantages only G.S. Gearing can give. Send along drawings or descriptions today.

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

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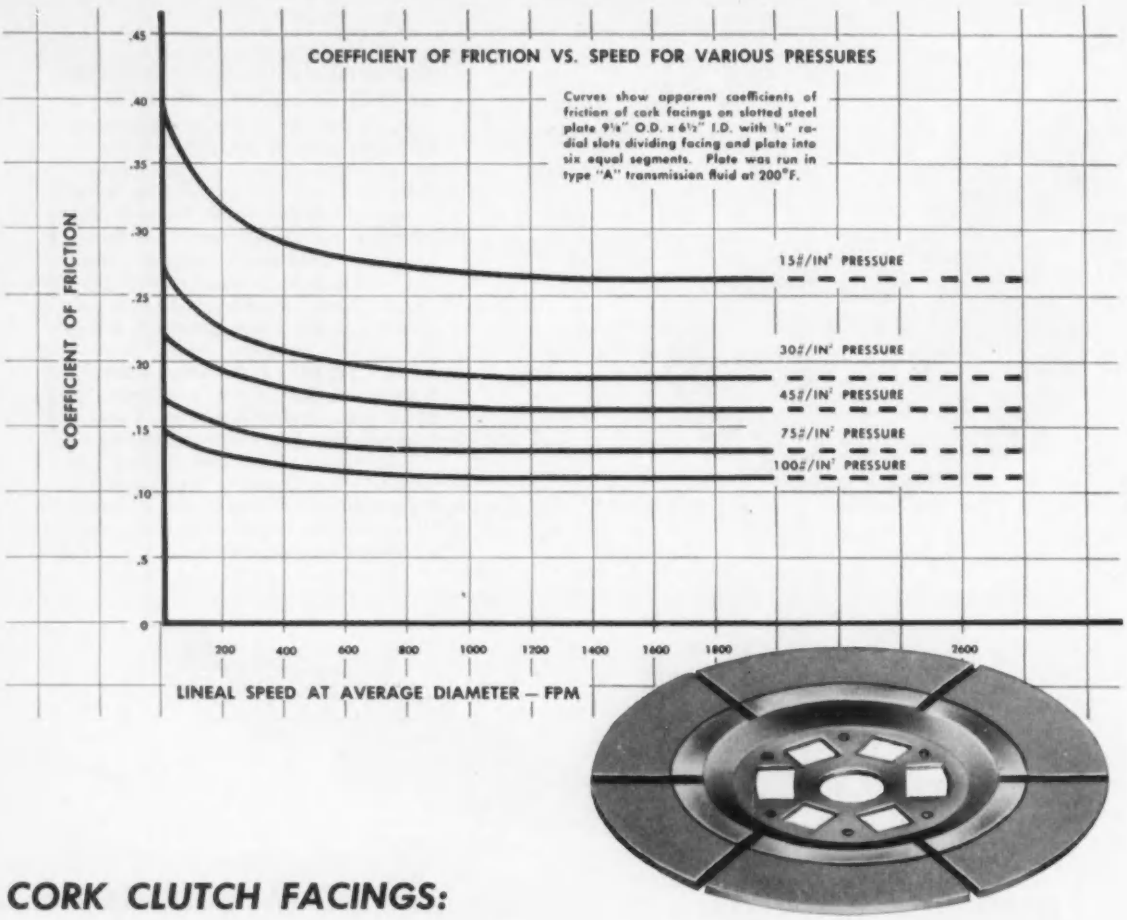
40 Years of Specializing in Small Gearing!



CORK CLUTCH FACINGS:

High torque capacity at low engagement pressures

The ability of cork facings to work efficiently at low engagement pressures helps clutch manufacturers get high torque capacity at relatively low cost. Savings in the number of plates or their size are often possible—and, in turn, savings in weight, space, metal, and friction material.

The chart above shows that a typical cork-compound clutch facing has relatively high coefficients of friction under engagement pressures as low as 15 psi. This kind of performance makes cork composition facings ideal for use in tractors, appliances, and industrial equipment, for example, where unit pressures of 20 psi to about 150 psi are normal.

The life expectancy of cork is amazingly long. In fact, Armstrong cork clutch facings in the automatic transmissions of 13 American makes of automobiles normally outlast the cars themselves.

Another design advantage of cork facings is the wide performance range that can be obtained by changes in the plate design or the cork compound itself. This flexibility gives designers wide freedom in clutch design which is of value whether their goal is cost reduction or performance improvement.

Perhaps cork's high torque capacity and dependable performance can be of help in your clutch design problems. We'll gladly help you choose the most efficient cork facings for your particular applications. Write to Armstrong Cork Company, Industrial Division, 7211 Irvin Street, Lancaster, Pennsylvania.

Armstrong FRICTION MATERIALS

. . . used wherever performance counts

is temperature compensated, and is unaffected by temperatures from zero to 350 F. Also, it has an automatic surge damping effect, as a positive change in level of sufficient duration to affect the heat tranfer rate is necessary before the switch will operate. This eliminates short-cycling caused by momentary changes in level, like vessels subjected to surging or vibration. Production will start next month at: Teddington Industrial Equipment Ltd., Sunbury-on-Thames, Middlesex, England.

ELECTRONIC COMPONENTS FOR HIGH TEMPERATURE OPERATION. . . .

. . . . are in long range Air Force plans. Indications show the need for electronic equipment capable of taking surrounding temperatures in the vicinity of 500 C. Investigation along these lines at Armour Research Foundation, Chicago 16, Ill., are to determine what present electronic components are suitable for operation at these temperatures, and to study materials which can be used as the dielectric in capacitors, and other materials for wire insulation.

RCA'S THREE MAJOR ADVANCES IN ELECTRONICS. . . .

. . . . announced earlier this year and last year, have some new applications. The previous electronic refrigerator with no moving parts has been increased in size, and its principles have been applied to an air conditioning system using large wall panels which become cold with the application of electric current. With a reversal of the current, the same panels produce a heating effect. The system uses no motors, fans, pumps or other moving parts. At its present stage of development the device can maintain a room temperature 25 deg cooler than the outside temperature. Used in reverse, the system will maintain a room temperature "considerably more" than 25 deg warmer than the outside temperature. Another development is a hear-see home magnetic player for television. Housed in a cabinet no larger than a high-quality magnetic tape sound reproducer, the new device can play over a standard television set the pictures and sound of television programs pre-recorded on magnetic tape. Work is progressing on the same system for color. A further development, the light amplifier, in the form of a thin flat panel, can increase by 1000 times the visual brightness of a project light. An amplifying fluoroscope for industrial X-ray use in normally lighted surroundings is one application.

AND IN ADDITION. . . .

. . . . Motorola's transistor manufacturing division are in pilot run production with a 500 mc transistor, but do not expect them to be used in products for two years. . . . A program is being conducted to predict the deterioration in performance of electronic equipment due to the presence of certain chemical dust particles in the air. . . . It has been reported that a large Ruhr (German) steel firm, Hoesch Werke, is conducting experiments to use metal fuels, such as compounds of aluminum and silicon, to get steel directly from the ores. Other rumors concern experiments with atomic smelting. . . . An automobile company is conducting experiments with metals in the neighborhood of absolute zero hoping to discover short cuts to the tailor-making of new alloys. . . . Dr. R. G. Breckenridge, Dir. of one Union Carbide and Carbon Corp.'s new research lab, says that within the next ten years the U.S. will need a minimum of 8000 physicists in the chemical and solid state physics fields. Of the 16,500 physicists in the U.S. today, 4000 are in these two fields; in the 1930's only 100 were in the field.

NEW CONTROLLER LINE ADAPTS 576 WAYS

Fenwal Announces Low-Cost Temperature Indicating Controllers

ASHLAND, MASS. — Fenwal Inc., has announced here that tailor-made, accurate, low-cost temperature indicating controllers are now available from stock.

Tailor-mades from stock are made possible by the development of the new Fenwal Series 541 line. The Series 541 is a standardized line of matched temperature indicating controller parts which can be combined easily in 576 ways.

From these possible combinations come perfect solutions to countless temperature control problems. A prospective user lists the characteristics of the ideal temperature indicating controller for his particular operation, and Fenwal assembles an instrument with those characteristics from parts in stock.

No matter what combination is chosen, the result is a rugged, accurate, compact and easily maintained unit in a shock-proof, splash-proof, dust-proof housing. The housing is available in colors to match any equipment in which it may be installed.

Installation and calibration are so simple that instrument technicians and laboratory procedures are unnecessary. And, after installation, all normal temperature adjustments are external.

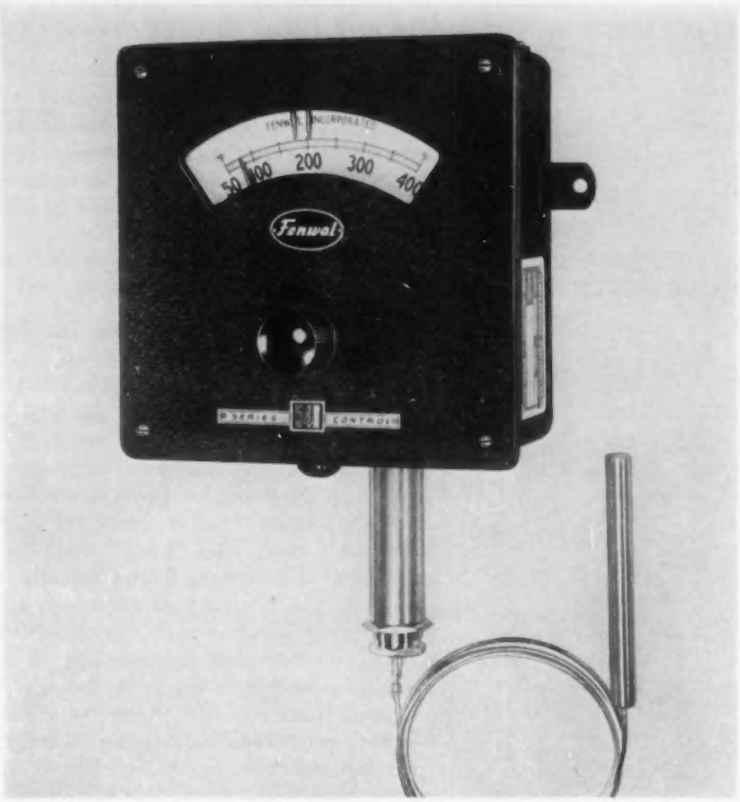
No matter what combination is chosen, the resulting instrument is accurate to within one per cent of scale. The accuracy is long lasting, with few moving parts and no internal gears. Simplicity of design brings the wear factor close to zero.

Series 541 offers single or double circuit control. There is a choice of four different long-life snap switches, with ratings up to 20 amps, 250 volts, A.C. These switches, singly or in combination, can provide a wide variety of operating characteristics.

Three stainless steel bulb types are available at no increase in price to meet space or process requirements. Capillaries and bulbs are corrosion-proof. Capillaries are swivel-mounted to protect them from breakage.

There is a choice of three temperature ranges: −150° to 200°F, 50° to 400°F, or 50° to 700°F, or their centigrade equivalents. Special ranges are available on request.

The control mechanism may be subjected to temperatures up to 150°F, and is ambient compensated from 50° to 150°F.



One of Fenwal's new Series 541, bulb-and-capillary controllers. Photo shows dual circuit model which has two snap switches, each with a setpoint indicator, that actuate two separate circuits at the pre-set temperatures.

Write to Fenwal Incorporated, 211 Pleasant Street, Ashland, Mass. Describe the tailor-made temperature indicating controller that would fit your operation perfectly. Chances are excellent that the tailor-made can be yours — at savings never before possible.

Fenwal

CONTROLS TEMPERATURE
. . . PRECISELY

Twice around the clock or less—and your order for TIMKEN® 52100 steel is on its way to you

ALL it takes is a phone call today to get your rush order of Timken® 52100 steel tubing on its way tomorrow. We ship within 24 hours of your order because we stock 101 different sizes of 52100 tubing—from 1″ to 10½″ O.D., all available for less-than-mill quantity orders.

Timken 52100 steel can save you money as well as time. It can be used in place of many more expensive steels for hollow parts jobs that call for a steel that's hard and tough, yet easy to machine. 52100 is through-hardening in moderate sections and can be heat treated to file hardness and tempered back to any desired point.

Timken 52100 steel is ideal for parts such as: aircraft parts, ball bearing races, pump parts and plungers, collets, bushings, spindles, grinding machine parts, precision instrument parts.

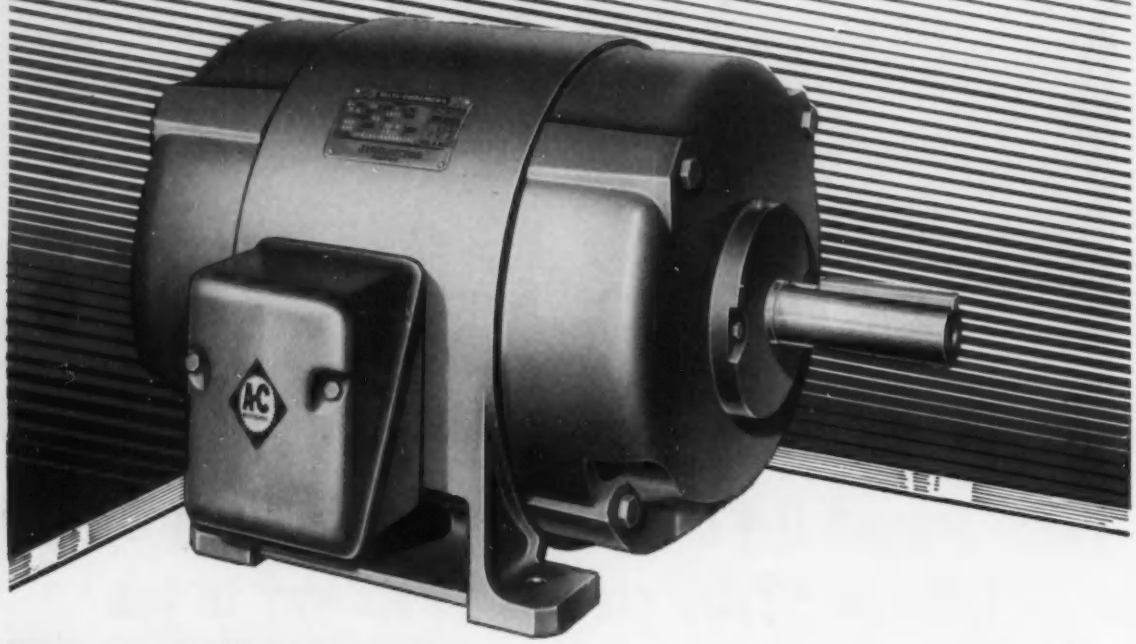
The Timken Company is America's pioneer producer of 52100 steel tubing, and the only company that makes this steel in tubing, bars and wire. Our unequalled experience assures you of uniform steel quality from tube to tube, heat to heat, and order to order.

For immediate delivery of your less-than-mill quantity orders of 52100 steel, write, wire or phone The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

NEW *Synduction* MOTOR



Do you have an Application Requiring . . .

. . . **Constant speed, regardless of load or voltage, depending only on frequency.**

. . . **Synchronized speed for a number of motors.**

. . . **Adjustable speed with minimum variation at any speed setting.**

Synchronous Speed with Induction Simplicity

Allis-Chalmers new development — the *Synduction* motor — offers these characteristics at low cost — with the dependability of an induction motor. In addition to constant speed from no load to pull-out, it also offers across-the-line starting, wide range of speeds and high efficiency. It's another example of MORE motor pioneering by Allis-Chalmers.

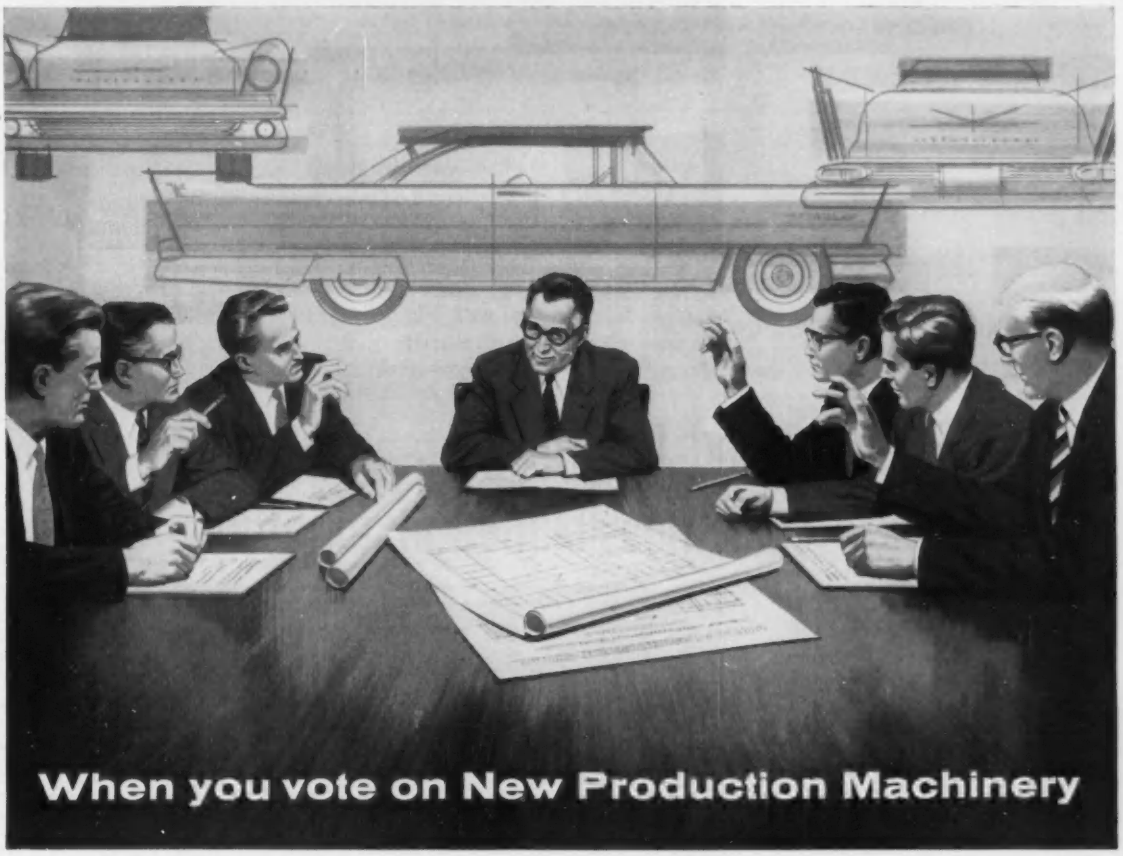
Allis-Chalmers invites your inquiry, in the belief that many processes can be improved by the application of *Synduction* motors. Our engineers will gladly analyze your present operations to help you determine where *Synduction* motors can be applied profitably. Call your A-C office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin, for Bulletin 51B8440.

Synduction is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

A-5115

ALLIS-CHALMERS



...do you vote a straight AMERICAN ticket?

There's no real substitute for American-made production machinery in any branch of American industry. Designed and built to take the strains and stresses of the world's toughest demands for speed and endurance . . . with a minimum of down-time and maintenance . . . American machines are today more than ever the best buy in every field from textiles to metal-working. Yes, American production machines are the backbone of America's competitive economy . . . *and why settle for anything else?*

VEEDER-ROOT INC.

"The Name that Counts"

Hartford, Conn. • Greenville, S. C. • Chicago
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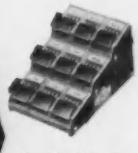
Offices and Agents in Principal Cities

. . . and here's why it pays to make sure that All New Machines you buy are equipped with NEW VEEDER-ROOT COUNTERS...

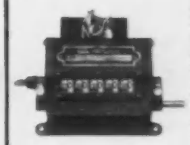
Modern Veeder-Root Counters are available for *building into* . . . or attaching onto . . . all types of production machines. They are built with unmatched Veeder-Root know-how and quality for years of accurate Countrol of production and uniformity. Ask your Industrial Supply Distributor or write Veeder-Root Inc., Hartford 2, Conn.



Hand Counting: Vary-Tally Multiple Unit Reset Counters for inventory, inspection and 1,001 hand-counting jobs. Up to 108 counters in 1 bank.

Mechanical Counting: Small resets count strokes, turns, pieces . . . are built into machine tools, light presses, etc.

Electrical Counting: Remote indicating counters (AC or DC) bring your production machines as close as your office wall. May be panel-mounted in groups.



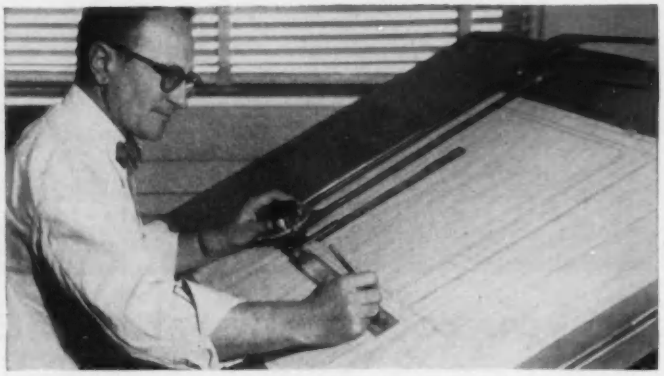
Controlling: Set for number of turns, pieces or operations required. Predetermining Counters control the run exactly . . . prevent over-runs and shortages.

Craftsmanship of the 20th Century

MONSANTO

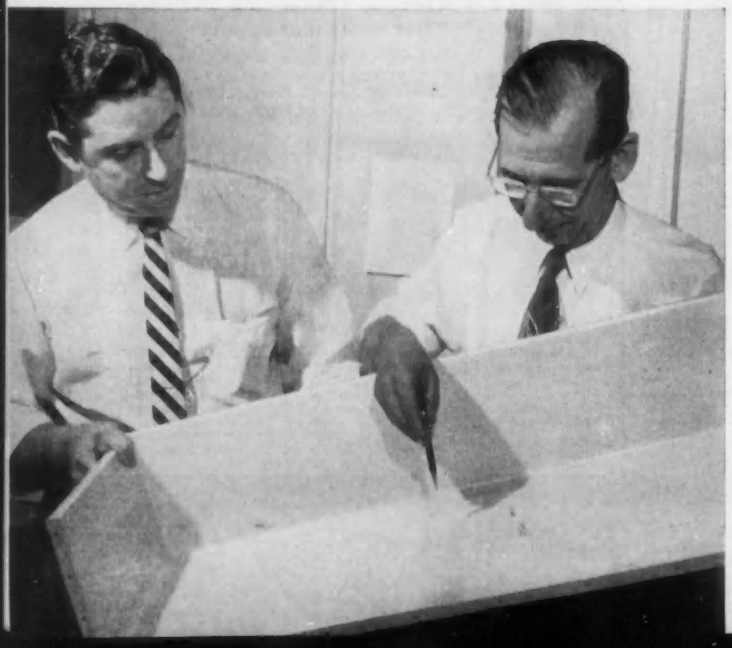
In modern merchandising, product ideas are "where you find them." They come from the selling agent. They come from the manufacturer. In today's Plastic Age, more often than not, they originate in the design department of the custom molder. Read how one of America's foremost merchandisers teamed with a leading custom molder to translate the unique properties of a plastic material into a new departure in furniture design.

GE, Sears, and Lustrex styrene plastic open up new color possibilities in furniture



DESIGN OBJECTIVE: a drawer for chests and nightstands that offered new color possibilities, ease of manufacture, economy, durability, and ease of care—without sacrificing the warmth, beauty, and acceptability of wood.

MATERIAL SPECIFICATIONS. The Chemical & Metallurgical Division of General Electric Company, working with Monsanto specialists, designed the answer—a 3-sided drawer molded in one piece of Monsanto high impact Lustrex styrene plastic. The fourth side—the front—was to match the case.



GE selected high impact Lustrex for many reasons. Color, for one—an unusually wide and varied range of lustrous colors. Fast moldability. Toughness. Dimensional stability—drawers molded of Lustrex would resist swelling or warping. Lustrex offered design flexibility—the one-piece molding could incorporate top runners, center guide flanges, compartments, and dividers. And the wooden side could easily be attached.

PRODUCTION of the drawers was by injection molding in 200 oz. presses at General Electric's molding plant at Decatur, Ill. The molding material was Monsanto Lustrex Hi-Test 88, a rubber-modified high-impact styrene.

THE FINISHED DRAWERS come in beautiful pastel molded-in colors. Their smooth rounded corners are easy to clean. There are no seams in the one-piece construction to dry out or spread. No additional finishing is required. The drawers fit snugly without fear of sticking in the cases made by Broyhill Furniture Factories, Lenoir, N. C., and Ward Furniture Co., Fort Smith, Ark., for Sears Roebuck. Featured in Sears' 1956 line of bedroom furniture, these drawers are making a major contribution to the growing trend to color in American homes today.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. The skill and experience of these 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Applications Dept., Room 908, Springfield 2, Mass.

Investigate the Monsanto completely-balanced line of styrene plastic compounds developed for particular applications and sold under the trade name . . .

LUSTREX®
Styrene Plastic

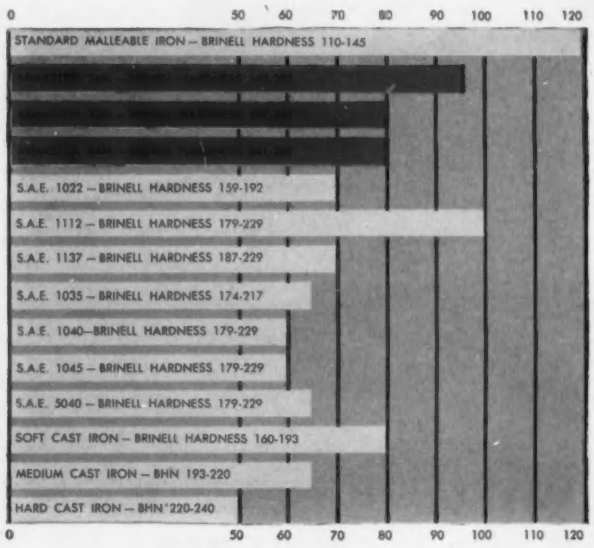
MONSANTO®

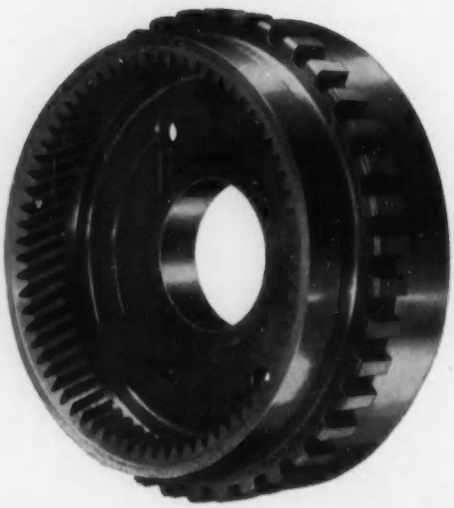
ARMASTEEL®

ArmaSteel's machinability makes it outstanding in the ferrous field. In general, its rating is from 10% to 30% better than bar stock or forgings of the same Brinell hardness. One of the reasons for this rating is the structure, which consists of a matrix of sorbitic-pearlite and spheroidized cementite in which small nodules of carbon are imbedded. Because of this the chips break off more readily in machining operations whether it be turning, drilling, milling or broaching.

The machinability rating of a metal is not absolute—its rating can be stated only in relation to that of another metal. To establish the accompanying machinability rating table Bessemer screw stock S.A.E. 1112 is used as the base. In establishing these ratings, the cutting speed of the S.A.E. 1112 is the rate generally used in turning this metal on automatic screw machines. The rate of feed, however, is altered to that necessary to attain normal tool life and good surface finish when using a coolant. When the other metals are tested, the feeds and speeds are varied from these basic rates to whatever rate is necessary to obtain comparable tool life and comparable surface finish. The ratio of these rates of speeds and feeds

MACHINABILITY RATING (PER CENT)





castings are easier to machine*

of each tested metal determines the percentage of machinability.

ArmaSteel is a versatile pearlitic malleable iron that combines the advantages of both castings and forgings. ArmaSteel parts can be cast by conventional sand method or shell mold process to relatively close dimensions in large quantities at low cost. Because of the excellent, accurately controlled physical properties of ArmaSteel, these parts have the strength and performance characteristics usually associated with plain carbon steel forgings.

ArmaSteel is produced in three ranges: ArmaSteel 84M, ArmaSteel 85M and ArmaSteel 86M with a wide variety of physical properties uniformly maintained through accurate heat treating operations as follows:

ARMASTEEL 84M is recommended where a high degree of strength is necessary. It usually replaces heat-treated steel parts in the 1040-1050 S.A.E. range. It has a hardness range of BHN 241-269 or 3.7-3.9mm. impression with a 3000 Kg. load. Tensile strength is 100,000 p.s.i., yield strength is 80,000 p.s.i., and percent of elongation in 2″ is 2.0%.

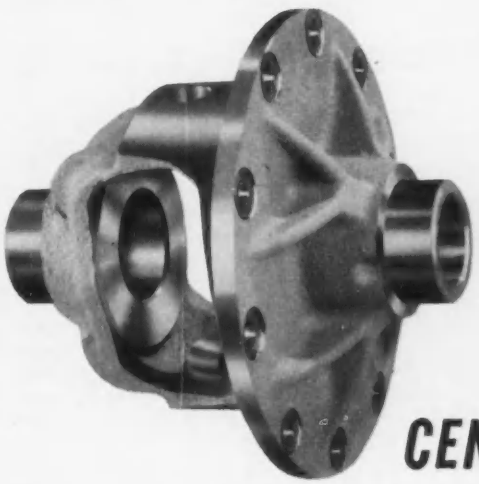
ARMASTEEL 85M is recommended where moderate strength is required and where selective hardening is necessary. This class usually replaces parts in the 1035-1050 S.A.E. range. It has a hardness range of BHN 197-241 or 3.9-4.3 mm. impression with 3000 Kg. load. Tensile strength is 80,000 p.s.i., yield strength is 60,000 p.s.i., and percent of elongation in 2″ is 3.0%.

ARMASTEEL 86M is recommended for less highly stressed parts usually replacing steel parts in the 1020-1035 S.A.E. range. It has a hardness range of BHN 163-207 or 4.2-4.7 mm. impression with 3000 Kg. load. Tensile strength is 70,000 p.s.i., yield strength is 48,000 p.s.i., and percent of elongation in 2″ is 4.0%.

The FOUR parts illustrated below are typical of the hundreds of different parts and products successfully produced in ArmaSteel for many diversified industries.

Write, today, for new 70 page comprehensive catalog . . . or request personal help from our experienced engineers, without obligation.

*When compared with medium carbon steel forgings.



CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

58

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

Designer's

Thymotrol* fhp adjustable-speed drives in full new line are more compact, cost less

A completely re-designed line of fractional-horsepower Thymotrol adjustable-speed drives—at new lower prices—is now offered by General Electric.

Thymotrol drives—comprising d-c drive motor, control panel, and control station—are applicable to conveyers, machine tools, and other small machines whose performance can be improved by adjustable speed. With a full range of ratings (economical half-wave units: 1/50 to ¾ hp; smooth operating full-wave units: ¼, ⅓, ½ hp) plus availability of a variety of optional performance features, you get exact matching of job requirements, pay only for as much drive as you need.

D-c drive motors provide outstanding performance on rectified power, supplying constant torque over the entire speed range. Open dripproof and totally enclosed constructions are standard, others are available.

Control panels electronically convert a-c to d-c power. They are housed in easy-to-install, NEMA Type 1 wall-mounted enclosures, with lift-off covers for easy maintenance.

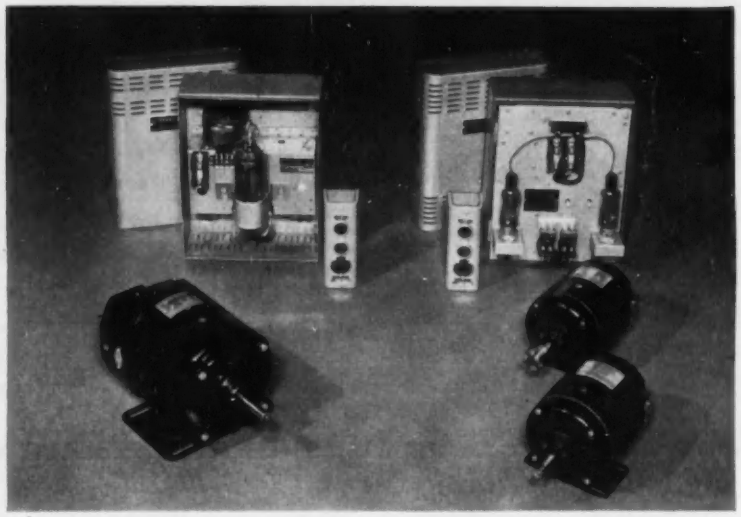
20:1 speed range and close speed regulation increase machine's versatility, permitting its use on a variety of jobs.

Printed circuitry contributes compactness and sturdiness, makes possible lower prices, faster delivery.

Dip soldering firmly secures panel board components to printed circuitry. Component replacement is fast, simple, requiring only a soldering iron and pliers.

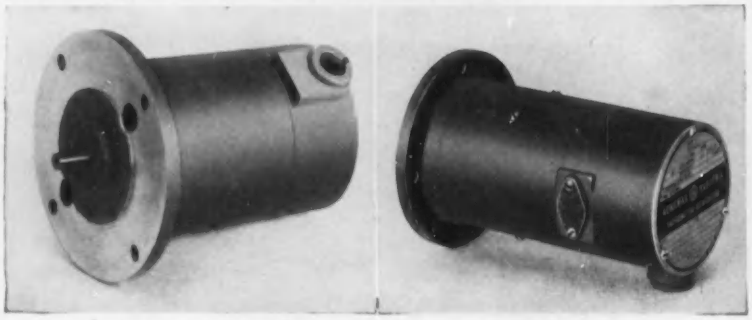
Single-tube design of half-wave Thymotrol drives emphasizes the unit's extreme simplicity of construction.

Plug-in panel boards facilitate rapid servicing. Complete panel can be removed or installed in ten seconds—without disturbing customer wiring—permitting a high continuity of production. Write for GEA-6519.



*Registered trade-mark of General Electric Co.

Lightweight tachometer generators measure speed ranges from 100 to 5000 rpm



A-c tachometer generator.

D-c tachometer generator.

When your machine tool application calls for speed indication of moderate accuracy, select G.E.'s compact tachometer generators which are only $3\frac{3}{16}$ inches in diameter. Weighing less than four pounds, the versatile four-pole a-c tachometer generators feature totally enclosed construction and serve speed ranges from 400 to 5000 rpm.

Two-pole, d-c, ball-bearing tachometer generators provide accurate speed ranges from 100 to 5000 rpm. These units weigh less than six and one-half pounds and can be used as a signal source in a speed regulated drive scheme. Write for GEC-1405.

GENERAL ELECTRIC

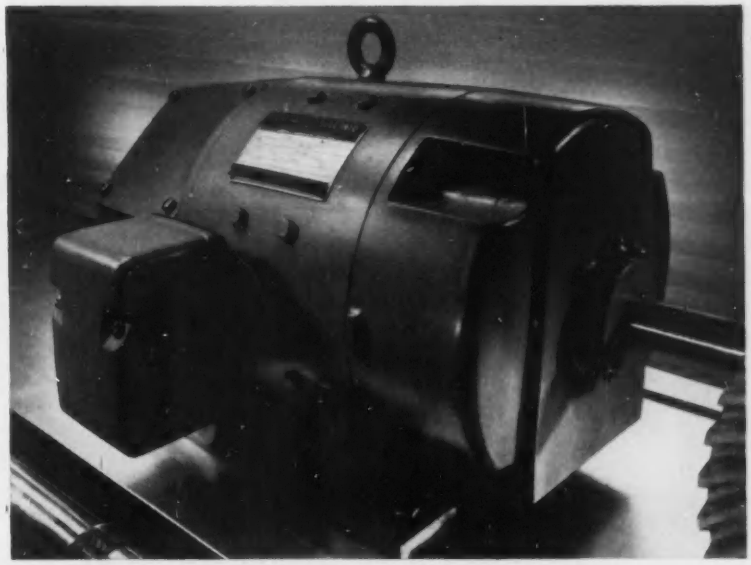
Digest

PRODUCT HIGHLIGHTS

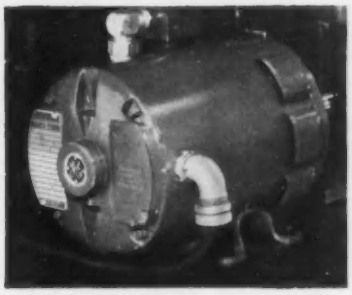
Versatility of new KINAMATIC† d-c motors simplifies motor selection problems

New General Electric d-c Kinamatic motors can meet modern industrial needs by performing either as an individual motor drive or in regulating systems. Their versatility and flexibility permit a wide variety of both constant- and adjustable-speed applications used today for automatic processing. These versatile features help designers simplify motor-selection problems. ***Adjustable-speed*** by armature voltage control, field strength control, or combination of both, provides the speed, torque, horsepower required in almost any sequence. ***For constant horsepower,*** higher operating speeds are obtained through field strength adjustments. ***For lower speeds,*** the d-c Kinamatic motor can operate over wide speed ranges including speeds far below base, even stalled conditions. Ratings from 1 to 150 hp are included in the line. See GEA-6355.

†*Trade-mark of General Electric Co.*

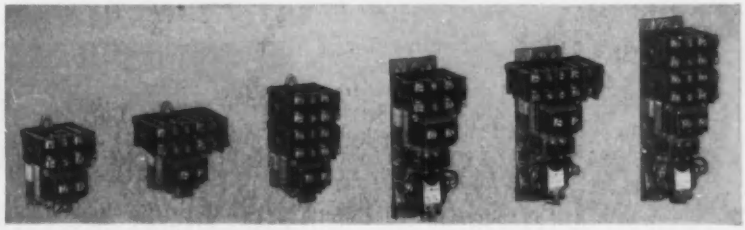


FHP machine tool motors factory lubricated for ten years



Special ball-bearing construction and new-type grease in G-E totally enclosed fan-cooled machine tool motors provide long, low-maintenance service and support heavy thrust loads. Sturdy welded-on base assures rigid mounting and accurate motor alignment; compactness simplifies assembly and design. These motors are rated ¼, ⅓, ½, ¾ horsepower in 60/50 cycles, 208–220/440, 220/380, 500 volts and are engineered to stand up under continuous start-stop service in heavy-duty industrial applications. See Bulletin GEC-1306.

New machine-tool relay family features long life, easy wiring



New General Electric machine-tool relays are now available with 2 to 8 poles, including a 6-in-line model with same mounting dimensions as the 4-pole form.

Relay contacts can be changed from normally open to normally closed without extra parts. Front-connected saddle-clamp terminals make wiring easy. Strongbox coils are protected against oil, moisture, and dust. Ratings are 10 amperes, 110–600 v, 25–60 cycles. See Bulletin GEA-6317.

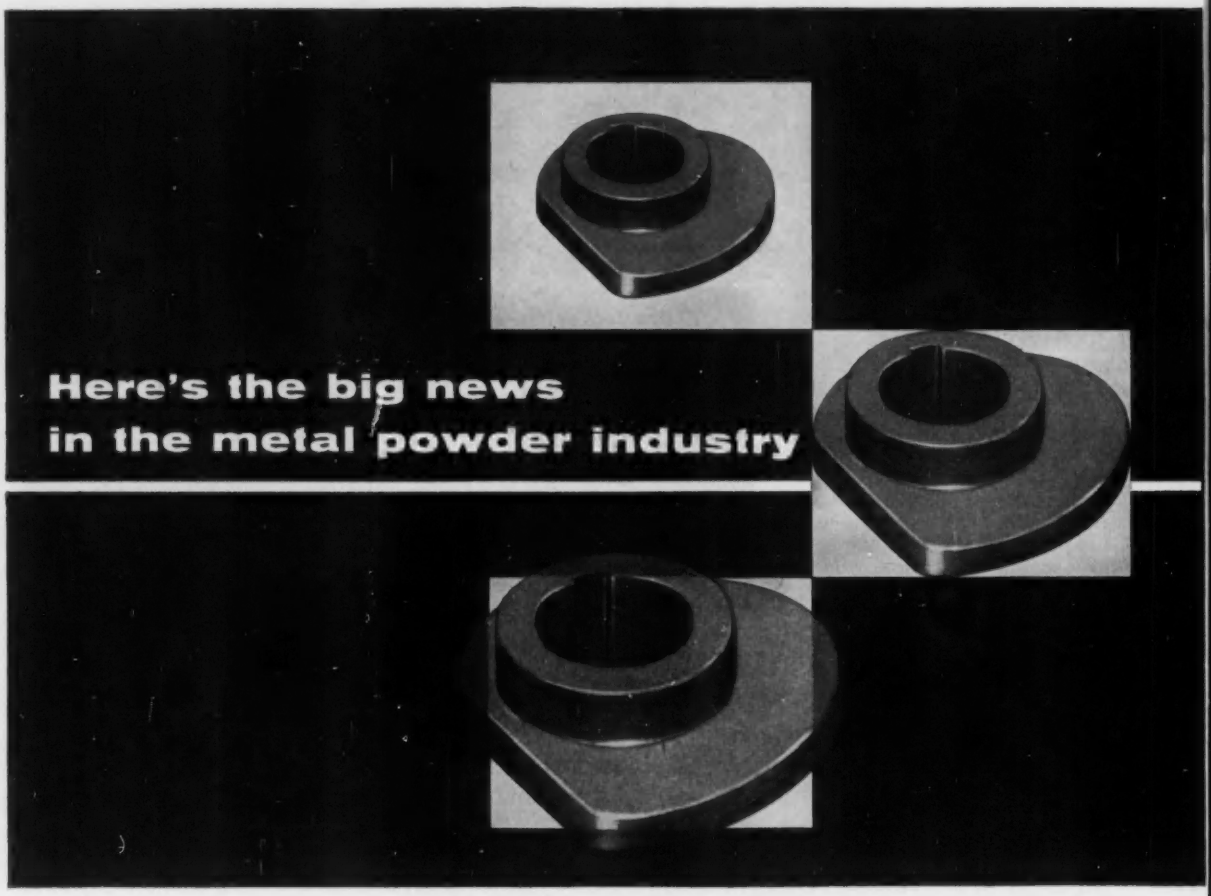
General Electric Co., Apparatus Sales Division, Section A668-133, Schenectady 5, N. Y.

Please send me the following bulletins:

√ for reference purposes		× for immediate project	
☐GEA-6317	Control Devices	☐GEC-1306	Fhp Machine-tool Motors
☐GEA-6355	Kinamatic D-c Motors	☐GEC-1405	Tachometer Generators
☐GEA-6519	Fhp Thymotrol Drives		

Name ..... Company .....

City ..... State .....



CONTROLLED QUALITY of tubular products starts with the carbon steel and stainless steel from which they are made. Republic ELECTRUNITE® Tubing is controlled for quality from ore to finished tubing. When you specify ELECTRUNITE Tubing you are sure of getting uniform diameter, wall thickness, concentricity, strength and ductility. These characteristics back your production facilities, simplify and speed output of superior parts like the immersion heater being fabricated at right. Mail the coupon for complete information.

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World's Widest Range of Standard Steels

REPUBLIC IRON POWDER with

Controlled dimensional factor

The Metal Powder Division of Republic Steel is now producing three types of Iron Powder, each with a variable controlled characteristic. This is called *Controlled Dimensional Factor.*

Simply stated, it means that in the presence of copper, Republic Iron Powder—depending on type—can be made to grow, shrink or remain stable within acceptable limits. The powders have been designated as Type S for shrinkage, Type G for growth, Type N for normal.

Think what this means to you as a producer or designer of iron powder parts. For example, suppose your dies have become oversize through wear. By using Type S powder, with a controlled shrinkage factor, you can continue to use those dies and still produce parts to specified tolerances.

Controlled Dimensional Factor is exclusive with Republic and the Republic production process. CDF is an addition to the excellent Republic chemistry. CDF powders are also available with apparent density ranges of 2.3 to 2.5.

For engineering service or more information on how CDF can be applied to your production of iron powder parts, send the coupon.

←
CONTROLLED PHYSICAL PROPERTIES and the cold finishing process performed on Republic Cold Drawn Steels provide dependability and economy in the manufacture of hinge pins and pivot ends on the Sherman Digger. Republic Cold Drawn Steels give these parts higher strength, greater hardness and a bright, smooth finish. They also provide top ratings on feeds and speeds, long tool life, freedom from abrasion and high product quality. Available in all carbon, alloy and stainless analyses.

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CONTROL COSTS on your stamped and drawn parts by using the top-notch production facilities of Republic's Pressed Steel Division. This truck pedal shaft bracket is one of a wide variety of steel parts mass-produced for large-volume manufacturers. Large or small, we handle them all. Your savings in handling, inventories, labor and overhead are reflected in reduced cost per piece. Booklet 681 describes the entire operation. Send the coupon.

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☐ Cold Finished Steels ☐ Stampings

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

Cylindrical Roller Bearing Inner Races

Their vital importance in bearing performance . . . advantages of carburizing . . . the manufacturing procedures which assure maximum quality and life

The function of an inner race is to provide a fatigue-resistant surface between a shaft and the rollers of an anti-friction bearing. Because of the geometry of a roller bearing, there is a smaller area of contact between the inner race and rollers than there is between the outer race and rollers.

This smaller area of contact has the effect of concentrating the loads on the inner race to a greater degree. Therefore, the inner race is always the critical member of a roller bearing from a fatigue life standpoint. When the inner race is the stationary member and the outer race rotates, this load concentration on the inner race is even more of a factor since the maximum load is repeatedly applied at one point.

Adequate resistance to relative movement between the inner race and shaft is vital to satisfactory performance. HYATT inner races are made of materials chosen to permit relatively heavy press fits. When HYATT press fitting recommendations are followed, the inner race becomes an integral part of the shaft for all practical purposes.

1. WHY CARBURIZING?

HYATT inner races are made of a good *carburizing* grade of steel, rather than through-hardened steel, for several reasons. First, carburizing permits the vital heavy press fits referred to above. Second, tough flanges that will not break out under impact can be obtained on carburized races with no loss of case hardness. Third, carburizing improves load-carrying capacity, as shown in Diagram A. During quenching, the phase change from austenite to martensite which occurs in the outer case is accompanied by a volumetric change; but the low carbon core remains tough and ductile *without* appreciable volumetric change. The result is a tendency to stretch the core and compress the case. Due to the Poisson effect, *the compressive hoop stresses in the external fibres build up the load-carrying capacity of the race.*

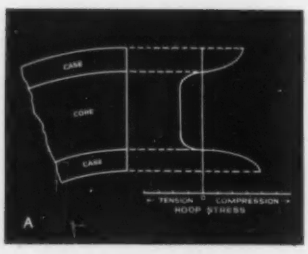
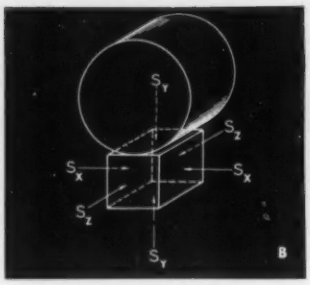


Diagram B shows a typical element of a HYATT carburized inner race under roller load. Stresses in the "Z" direction are negligible. Stresses in the "X" direction are compressive hoop stresses or preload. Stresses in the "Y" direction are compressive stresses due to the load. Without the compressive stress Sx (hoop stress) the load-carrying capacity would be less; and should the stress in the "X" direction become a tensile stress due to pressing a through-hardened race on a solid shaft, the capacity would be still further reduced. Reference to applicable theories of material failure will support this view and indicate why HYATT has gone to substantial added expense to give customers the benefits of carburized inner races.



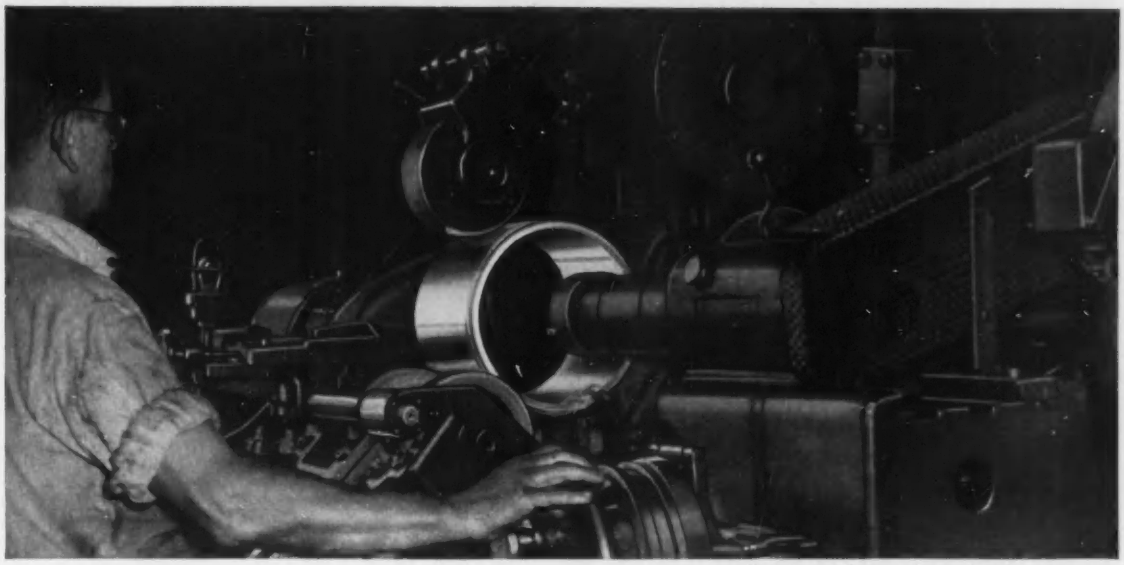
2. OPERATIONAL REQUIREMENTS

A top-quality inner race should have all the following characteristics:

1. *Minimum wall variation:* Concentricity of the inner race pathway to bore is necessary for quiet operation at full bearing capacity.
2. *Minimum runout of race ends to bore:* The bearing must not be cocked on the shaft by location against a square shoulder with a race end having excessive runout.
3. *Minimum runout of race flange inner faces to bore:* Excessive flange face runout results in noisy operation and hunting of the shaft.
4. *Minimum bore tolerance:* An important fitting consideration. If all the available tolerance is taken in the race bore, the shaft tolerance is unnecessarily restrictive.
5. *Minimum pathway and bore taper:* Taper causes uneven roller loading with resultant overheating and poor life.

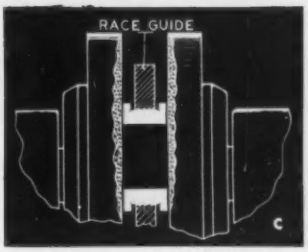
3. MANUFACTURING PROCEDURES

Good control of primary machining is reflected in good quality of the finished product. The early stages of manufacture, through the heat treating operation, are highly important and are all scrupulously controlled by HYATT. In this article, however, the *finishing operations* are of primary interest and will be discussed in detail.



Centerless grinding operation on a large Hyatt inner race.

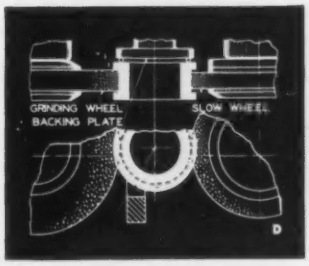
4. DOUBLE END GRIND



The sequence of grinding operations is important. The ends must first be faced off *square and parallel* so that during subsequent operations the ends can be used as accurate reference. The HYATT double end grind operation illustrated in Diagram C insures excellent control of race end parallelism.

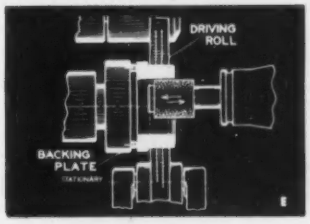
5. CENTERLESS PATHWAY GRIND

The centerless grinding principle was pioneered by HYATT many years ago. This method was a significant improvement over existing chucking methods because it eliminates excessive wall variation introduced by spindle and chucking errors.



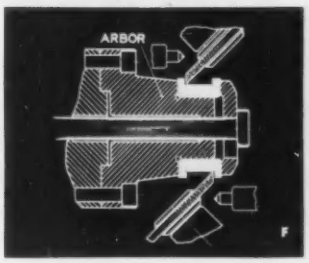
The race pathway is ground by the centerless method to produce a race with as nearly a perfectly round diameter as is commercially practical. Two-point and three-point out of round as well as taper are held to a minimum. Note that the work is rotated with a backing plate against the previously ground end, as shown in Diagram D.

6. CHUCKLESS BORE GRIND



Here again the centerless method is employed to generate an inner diameter (bore) concentric with the outer diameter (pathway.) This is accomplished by driving the race on the outer diameter and positioning the grinding wheel relative to the drive roll. The result is maintenance of minimum wall variation by removing stock from the high spots as they pass between the drive roll and the grinding wheel, as shown in Diagram E.

7. FLANGE GRINDING



All flange faces must be ground to run true with the roller pathway. Since the pathway and bore have been ground using the ends as a reference, the ends are also used as reference while grinding the flange faces (Diagram F). This establishes all-important even contact with the roller ends during operation of the bearing.

8. VIGILANT INSPECTION

Strict inspection is vital to the maintenance of high-quality standards in a precision product such as roller bearings. Working with the finest test equipment under conscientious supervision, highly trained HYATT inspection teams constantly watch the quality of HYATT parts as they are produced. This insures traditional HYATT dependability.

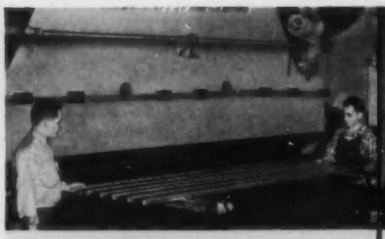
YOU WILL FIND FURTHER DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

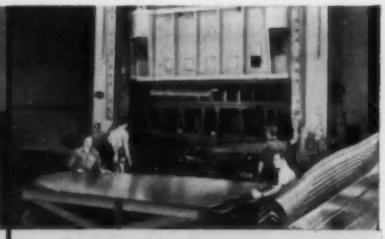
HYATT

HY-ROLL BEARINGS FOR MODERN INDUSTRY



Square corrugated trailer siding fabricated on brake press. Reynolds has available brake presses ranging from 22½ to 300 tons.

Washing machine tubs fabricated here are one example of countless quality parts fabricated by Reynolds.



1700-ton hydraulic press in a Reynolds plant used on 12' x 4'8" aluminum boat hull. Press is currently used on drawn parts 6' in dia.

from tumblers to trailers... get the most from your designs with

ALUMINUM

PRESS PARTS

fabricated and finished by REYNOLDS

If your designs call for aluminum parts that require blanking, punching, drawing, forming, stamping, piercing or other press operations, Reynolds can fabricate these parts—and finish them—to your specifications quickly, efficiently and economically.

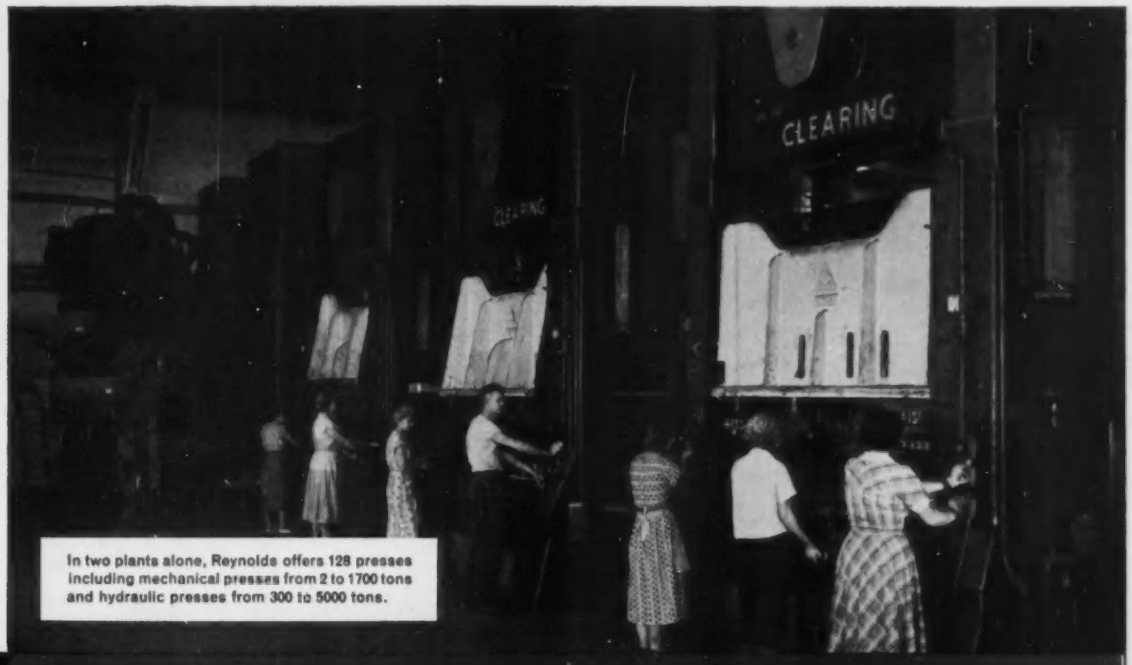
The great variety of Reynolds specialized equipment gives you the economy of the machines best suited to your purpose without making the tremendous capital investment in equipment and added plant capacity which would otherwise be required. Reynolds can furnish press parts from simple blanks to deep drawn parts of large area; from very thin to the thickest aluminum that can be drawn.

And—when an unusually high quality finish is important to the sales appeal of your aluminum product—Reynolds expanded finishing facilities are your best source for clear anodized, color anodized, chemically brightened or other fine finishes. Reynolds quality control from mine to finished product and Reynolds experienced design and engineering service go hand in hand with these facilities to assure you the most from your designs.

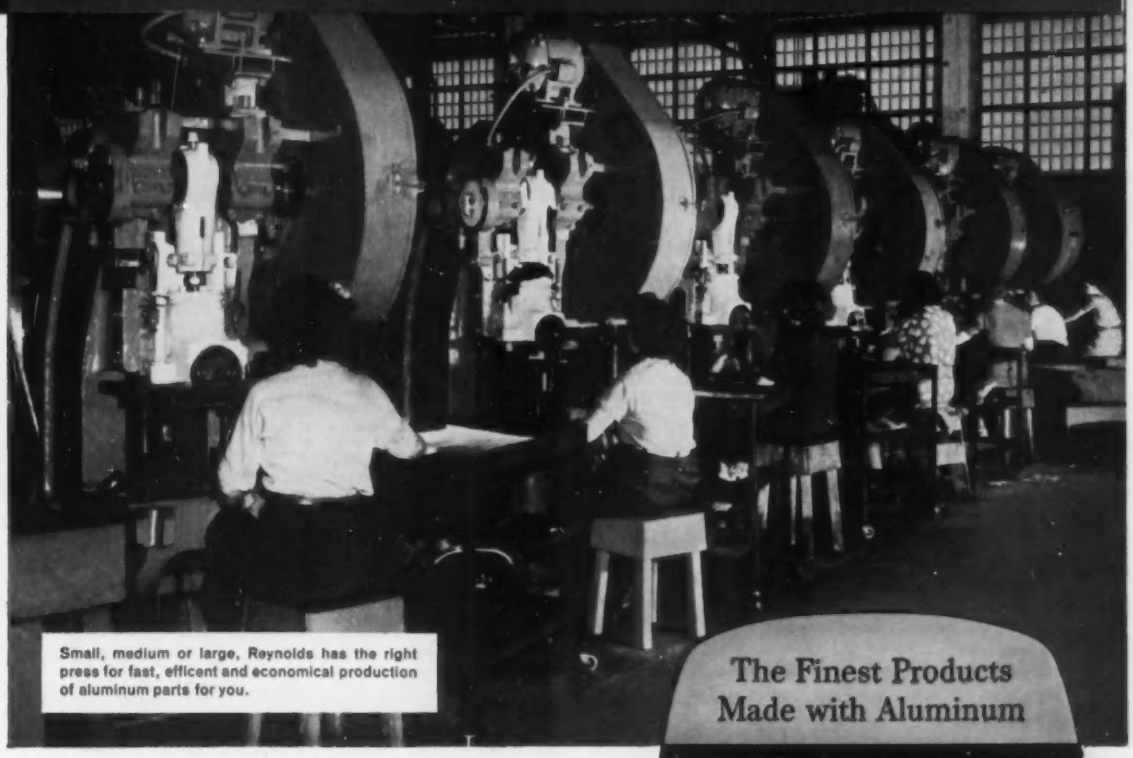
For full details on press parts and other services, call the Reynolds Office listed under "Aluminum" in your classified telephone directory or write *Reynolds Aluminum Fabricating Service, 2061 South Ninth St., Louisville 1, Ky.*

Watch for Reynolds new program, "Circus Boy"—Sundays on NBC—TV

REYNOLDS ALUMINUM FABRICATING SERVICE



In two plants alone, Reynolds offers 128 presses including mechanical presses from 2 to 1700 tons and hydraulic presses from 300 to 5000 tons.



Small, medium or large, Reynolds has the right press for fast, efficent and economical production of aluminum parts for you.

The Finest Products Made with Aluminum

are made with

REYNOLDS ALUMINUM

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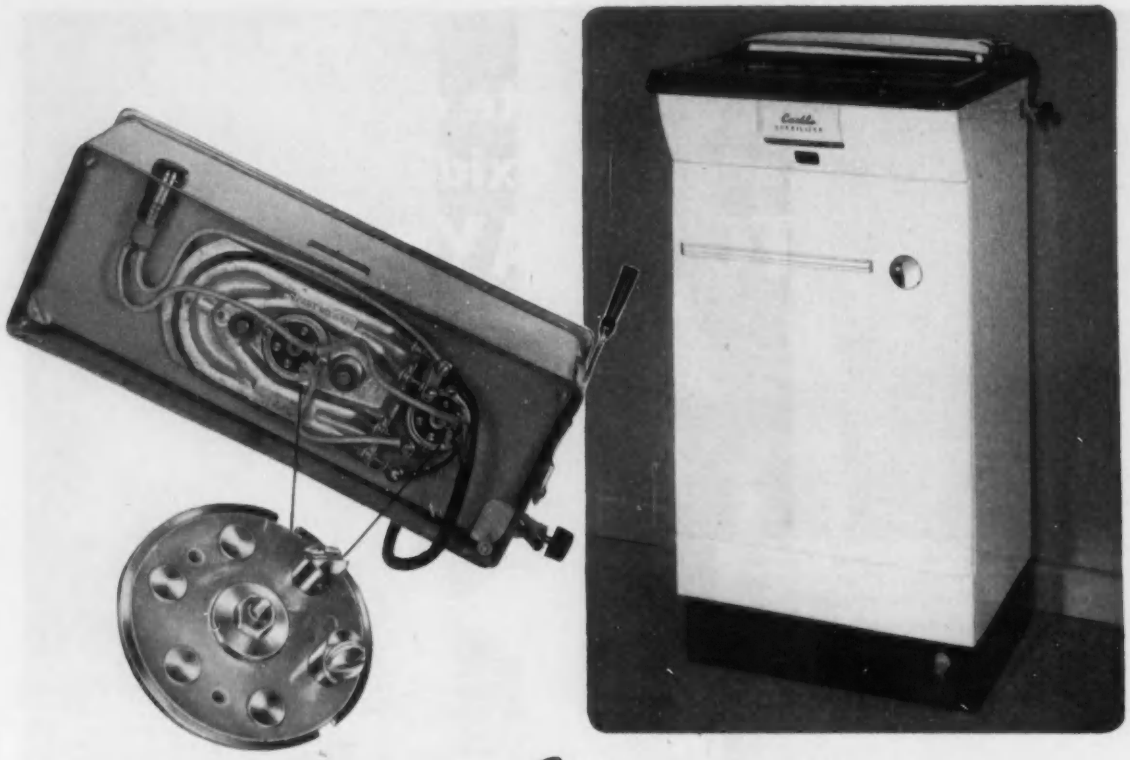


KLIXON *Thermo Snap*® CONTROLS

"Used Continuously Through 27 Years in Castle Sterilizers for Accuracy and Dependability"

For over fifty years, the Wilmot Castle Company of Rochester, New York, has specialized in quality sterilizers for physicians, hospitals and dentists. And today, Castle equipment is the recognized standard.

Since first used in 1927, Klixon Thermo-Snap Temperature Controls have helped Castle maintain this enviable reputation by providing accurate, dependable performance. Mr. David Bellamy, Advertising Manager, writes:

> "This company began using the "Klixon" Thermostatic Control in 1927. It was chosen then as a revolutionary idea for direct control of electric current because its speed and surety of action eliminated hazards then common to mechanical thermostats.
>
> "That early confidence has been proven justified through 27 years of continuous use in Castle Sterilizers."

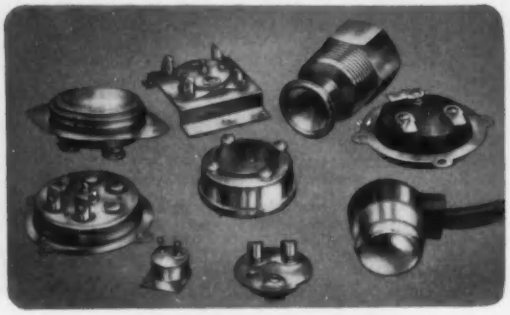
Designers and manufacturers seeking accuracy and efficiency in temperature control rely more and more on Klixon Thermo-Snap Controls, actuated by the famous Spencer Disc.

What's your temperature control problem . . . low and high temperature limitation, fuel delay switches, tube and rectifier cooling thermostats, fan switches, appliance controls . . . Klixon Thermo-Snap Controls are meeting hundreds of requirements for these and other applications in military and civilian products, daily.

Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

Our Field Engineers, specialists in temperature control applications, can help you work out your specific application details. Write for their help or further information without obligation.

Typical Klixon Thermo-Snap Controls that can help you solve your Temperature Control Problems



KLIXON

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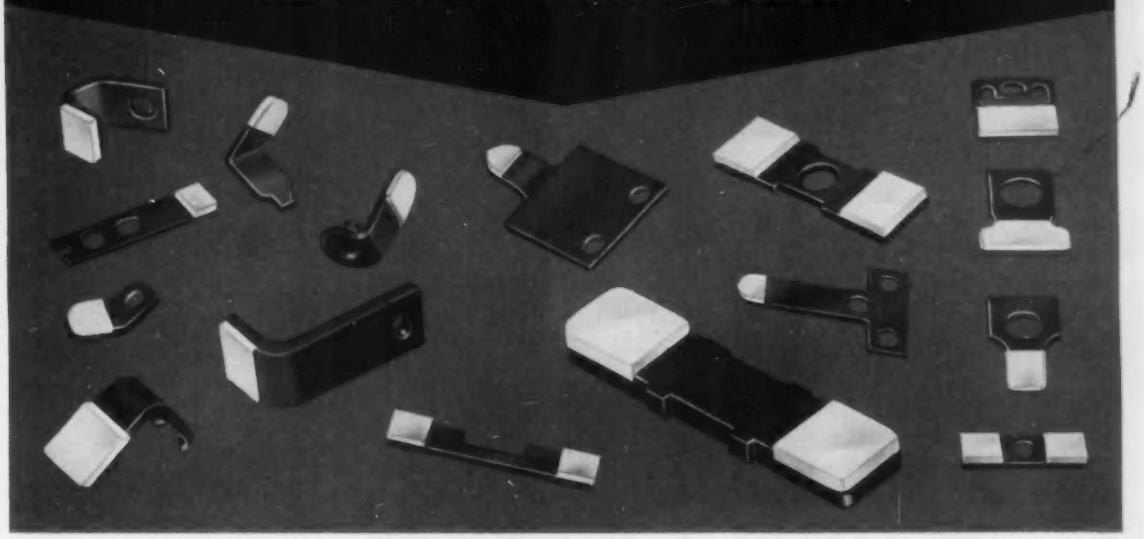
METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
2811 Forest Street, Attleboro, Massachusetts

NOW...General Plate can give you Silver-Cadmium Oxide Contacts in TOP-LAY Form



General Plate development and volume production of Silver-Cadmium Oxide clad as TOP-LAY now means you can get all of the advantages of Silver-Cadmium Oxide and TOP-LAY combined:

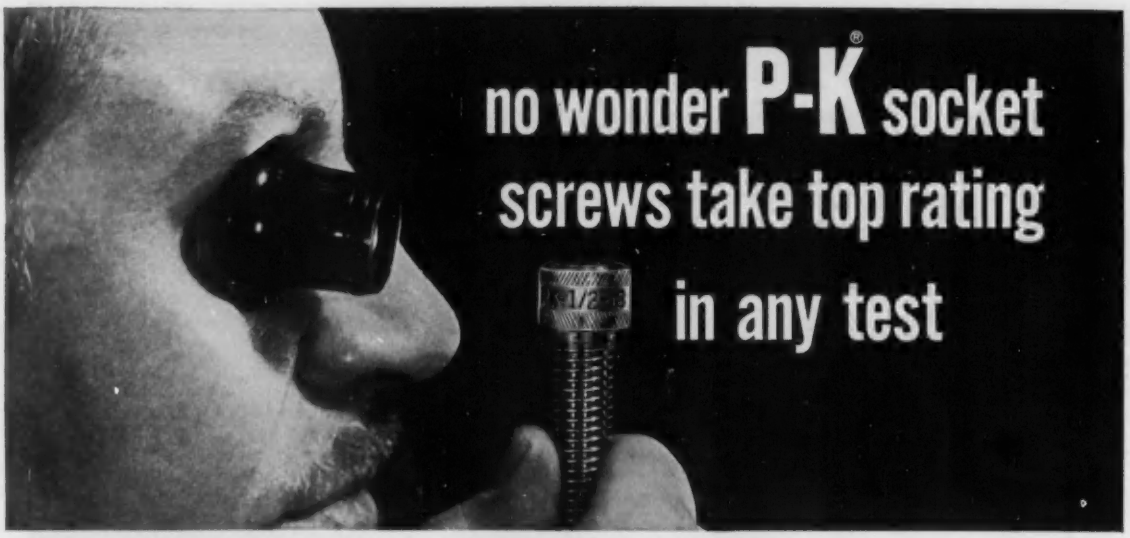
- ★ **Silver-Cadmium Oxide, properly applied, is an outstanding contact material — unusual in its ability to resist arc damage.**
- ★ **High work-hardness and density of both contact facing and backing, blanked or formed from TOP-LAY reduces mass and deformation . . . prolongs contact life.**
- ★ **Thermal and electrical capacities are increased when compared with Silver-Cadmium Oxide contacts made by conventional methods.**
- ★ **The problems of brazing — atmospheres, cleaning and fixturing — are eliminated.**

These Silver-Cadmium Oxide TOP-LAY advantages, plus the many other advantages offered by General Plate clad metal contacts, produce assembly accuracy, design freedom, substantial cost reductions and performance improvements.

Benefit today from General Plate's new Silver-Cadmium Oxide TOP-LAY . . . for complete information, write for Bulletin 728.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
1011 FOREST STREET, ATTLEBORO, MASSACHUSETTS



no wonder P-K® socket screws take top rating in any test

ROCKWELL HARDNESS TEST. With this familiar laboratory device, the hardness of screws is carefully tested as a check on heat-treatment.

PERFORMANCE. Both the raw material and finished screws are tested on this equipment to determine ductility and strength under tension loads.

HEX DIMENSIONS. To make sure that the hex meets exacting specifications, a team of inspectors check dimensions across flats at the machine.

HEAD DIAMETERS. As heads are shaved on automatic machines, such as those shown here, constant checking by operator and inspector maintains accuracy.

THREAD CONTOUR AND LEAD. The Comparator permits checking of thread contour and lead of screw heads against Class 3A Tolerances.

SEE FOR YOURSELF

These are just a few of the steps in the rigorous test and inspection routine conducted in Parker-Kalon's modern fastener plant. Exacting quality control assures that all "doubtful screws" are eliminated—that every P-K Socket Screw delivered to you is first quality. Parker-Kalon guarantees that it's first quality. In strength, dimensional accuracy and overall uniformity, you can be sure . . . "if it's P-K, it's O.K."

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

PARKER-KALON® fasteners

Sold Everywhere Through Leading Industrial Distributors
Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

DU PONT
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Better Things for Better Living . . . through Chemistry

PRODUCT ENGINEERING NEWS
PROPERTY AND APPLICATION DATA
ON DU PONT "ZYTEL" NYLON RESIN
NO. 7, 1956

Many design improvement opportunities possible with ZYTEL® nylon resin

PRODUCTS molded from ZYTEL nylon resin are light in weight, strong and tough even in thin sections. They are resilient, resist permanent deformation and absorb shock and vibration. ZYTEL retains its form stability at high temperatures and its impact strength and flexibility even below zero. Parts of ZYTEL offer high hardness, excellent abrasion resistance and low coefficient of friction—require little or no lubrication for long service and quiet operation.

In addition to these superior mechanical properties, ZYTEL is unaffected by oils, grease, electrolytic corrosion and most solvents or chemicals. ZYTEL fits into many electrical applications because of its heat resistance and insulating properties.

Du Pont ZYTEL is readily molded to close tolerances and easily machined on standard metal-working equipment. You'll find that articles of ZYTEL provide superior performance at substantial savings in cost.

Examples of improved product design shown on the following pages illustrate the unusual versatility of Du Pont ZYTEL for mechanical parts. Abrasion resistance, impact strength and low coefficient of friction of ZYTEL result in quieter operation and superior performance with reduced maintenance for bearings, gears and cams. Light in weight, strong in thin sections, and able to be accurately molded into complex shapes, ZYTEL often permits simplified one-piece design to replace an assembly of parts. Because ZYTEL is inert to oils and most chemicals—retains its properties at high or low temperatures—it finds many applications where ordinary materials would quickly fail.

Check the designs on the following pages. You may find that, by incorporating parts molded of ZYTEL nylon resin in your product, improved performance and reduced costs will result.

Complete property and application data on Du Pont ZYTEL are available to you. Mail the coupon on the last page of this insert.

OVER

The valve housing of this automatic home washer is an example of the design improvement possible with ZYTEL. The inlets of the solenoid-operated Dole Water Control Unit provide a leakproof connection with standard hose couplings. The resistance of ZYTEL to water and chemicals prohibits corrosion, reducing maintenance and replacement costs. (Valve molded by Chicago Molded Products Corporation of Chicago, for The Dole Valve Company, Chicago, Illinois.)

PRODUCT ENGINEERING NEWS

DU PONT

PROPERTY AND APPLICATION DATA ON DU PONT "ZYTEL" NYLON RESIN

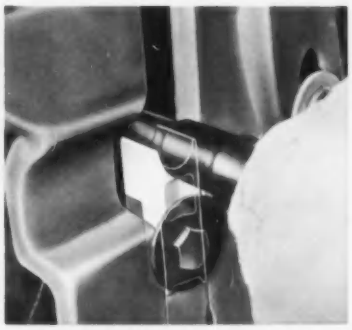
Better Things for Better Living ... through Chemistry

NO. 7, 1956

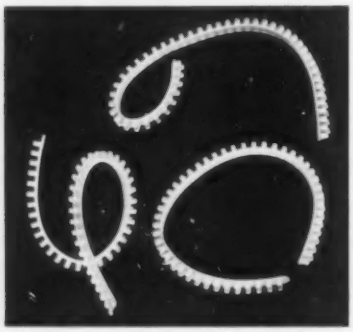
18 product

These counter wheels are molded in two different colors from ZYTEL. Light in weight, ZYTEL enables faster movement of the wheels with less power and a minimum of noise. (Manufactured by Electric Manufacturing Co., Inc., San Francisco, California.)

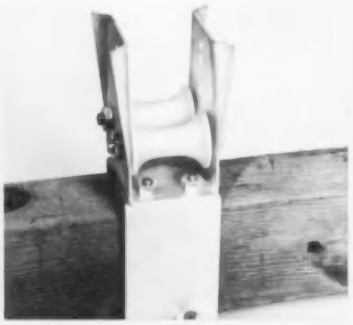
Nylon-lined sleeve-type bearing is composed of metal shell with molded lining of ZYTEL. Lining allows rapid heat dissipation and resists deformation, permitting high unit loading. (Produced by Nylacore Corporation, Glen Cove, New York.)



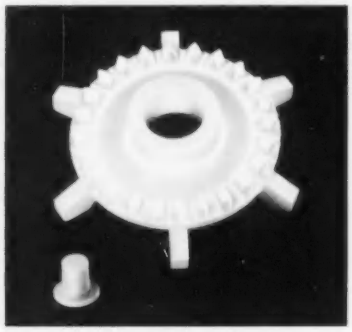
This cloth-roll bearing used in looms is made of ZYTEL, because it wears longer—requires little or no lubrication. ZYTEL replaced other materials which wore out from lack of lubrication. (Manufactured by the H. F. Livermore Corporation, Boston, Massachusetts.)



Grommets of ZYTEL are flexible and strong in thin sections—protect wire insulation from chafing in eyelets of any size or contour. These grommets are quickly cut and fitted from a 10-inch "Caterpillar" strip. (Manufactured by Nylon Molding Corporation, Garwood, N. J.)

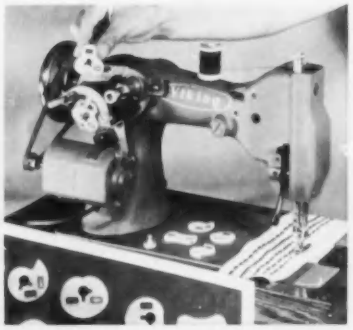


Cable stringing block is equipped with spools of ZYTEL which are abrasion-resistant and tough—will not damage cables. (Processed by Engineered Products, Inc., Kirkwood, Missouri for D. H. S. Company, St. Louis 17, Missouri.)

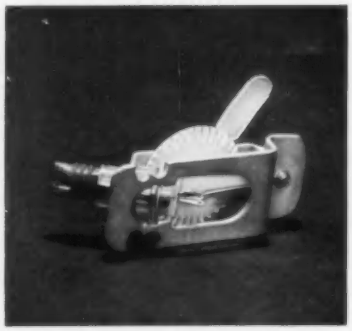


Oil slinger gear of wear-resistant ZYTEL operates quietly and withstands high temperatures inside an air-cooled engine. Stop switch button of ZYTEL stays cool even when engine is at 200° F. (Molded for Briggs and Stratton Corp., by Sinko Mfg. & Tool Co., Chicago.)

The belting of this photo processing machine is made of ZYTEL—is unaffected by developing and cleaning solutions. ZYTEL has high tensile strength, even in thin sections, and is resilient and flexible. (Belting produced by The Polymer Corporation of Pennsylvania, Reading, Pennsylvania.)



Interchangeable cams of ZYTEL in this sewing machine provide variations in stitching patterns. ZYTEL simplifies production, lowers costs due to ease of molding. (Molded by Boonton Molding Company, Boonton, New Jersey, for Consolidated Sewing Machine Corporation, New York, New York.)

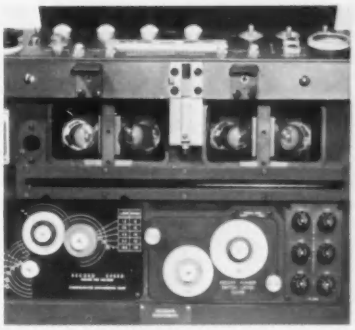


Phonograph needle holder of ZYTEL is molded into intricate shape and holds switching mechanism for different speed needles. Important in this application are the good dielectric properties and toughness of ZYTEL. (Phonograph needle holder manufactured by Electro-Voice, Buchanan, Michigan.)

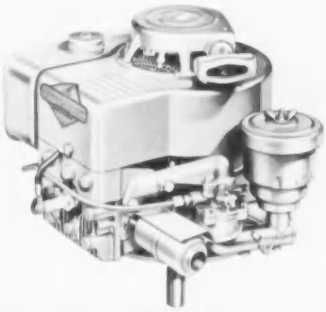
examples of improved design with ZYTEL® nylon resin

The rollers of this bread cooling equipment are manufactured under the Sanitation Code. Over-all performance of ZYTEL is found superior to that of metal. (Molded by United Plastics Industries Inc., Vassar, Michigan, for Baker Perkins Inc., Saginaw, Michigan.)

The cams which control the indexing of this rotary switch are made of ZYTEL. Because of its durability and strength qualities, ZYTEL replaced another material. (Molded for Cutler-Hammer Inc., by Sinko Mfg. & Tool Co., Chicago, Illinois.)



This recording oscillograph contains parts made of ZYTEL which give improved performance and provide accurate measurement in all phases of operation. (Manufactured by Consolidated Electrodynamics Corporation, Pasadena, California.)



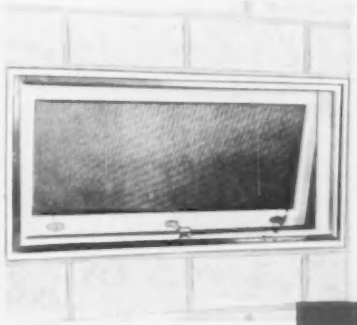
The bumpers for the starter pulley of this engine are made of ZYTEL, are adaptable to mass production. Quiet operation and longer wear result, because ZYTEL requires little or no lubrication. (Engine produced by Briggs and Stratton Corporation, Milwaukee, Wis.)

Bushings in a new sealed journal box Kit are made from ZYTEL. Important in this railroading advancement is the ability of ZYTEL to withstand extremes in temperature. (Manufactured by National Motor Bearing Company, Inc., Redwood City, California.)

The gears, bearings and blades of this mixer are made of ZYTEL because it is light in weight and resistant to heat, wear and corrosion. The Maynard Manufacturing Company of Glendale, California, expects these parts made of ZYTEL to outlast useful mixer life.

This pneumatic sump pump, run by air pressure, contains four vanes of ZYTEL. Driven at high speeds, the vanes are resistant to wear and are molded to extremely close tolerances. (Molded by Ingwersen Manufacturing Co., Inc., Denver, Colorado, for Gardner-Denver Company, Denver, Colorado.)

Tip jacks of ZYTEL have high dielectric strength, resist heat, cold and moisture, and stand up to high voltages under rugged operating conditions. Threaded insulating sleeve of ZYTEL with standard tip jack provides superior connector. (Manufactured by E. F. Johnson Company, Waseca, Minnesota.)



The latch on this window assures long-time service, because of the toughness, abrasion-resistance and high-impact strength of ZYTEL. (Molded by DuBois Plastic Products, Inc., Buffalo, N.Y., for Curtis Companies, Inc., Clinton, Iowa.)

OVER

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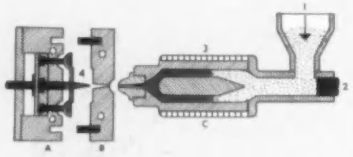
PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON DU PONT "ZYTEL" NYLON RESIN

NO. 7, 1956

Injection molding process is rapid production method

INJECTION molding is one process for producing large quantities of plastic parts. A typical injection-molding assembly, shown in the diagram, operates as follows:



Parts marked *A* and *B* close and lock to form the *mold;* they move to contact part *C*, which contains molten plastic. Measured quantities of the granulated plastic (*1*) are fed into the machine. The reciprocating *ram* (*2*) forces this material into the *heating chamber* (*3*), where the powder liquefies. Each forward motion of the ram (*2*) forces molten plastic into the closed mold (*A* plus *B*), where the plastic solidifies and forms the *molded part* (*4*). Then the mold opens as shown in the diagram and the plastic part is ejected. In the meantime, the ram moves back, allowing more powder to feed into the machine, preparing it for another molding cycle.

The production rate depends on a number of variables, including the size of the part and the number of identical cavities cut into the mold. If molded parts are small, dozens of them can be made at one shot, whereas large parts may be produced one at a time. Cycles of 1 or 2 moldings a minute are not uncommon.

Here are some of the advantages of injection molding:

1. High rate of production
2. Economical production in quantity
3. Little or no finishing cost
4. Parts molded to close tolerances.

Economical and durable control switch made with ZYTEL® nylon resin

The durability and impact resistance of ZYTEL permit reduced costs in the Saxony switch, because less wall thickness is required. The multiple switch controls the temperature of electric heating pads and is molded by Wilmington Plastics, Wilmington, Del., for Saxony Electronics of Wilmington.

FUNCTION and appearance, coupled with cost, are important factors in the design of a new product. Because of this, the Saxony multiple switch, which controls the temperature of electric heating pads, is molded of ZYTEL.

ZYTEL was chosen for the Saxony switch because of its durability and impact strength, even in thin sections. The thinner walls of ZYTEL result in economy of material, and a reduction in costs.

Its low coefficient of friction gives ZYTEL excellent bearing characteristics. For this reason, the moving parts of the switch are also molded of ZYTEL nylon resin.

Available in white and in a wide range of colors, ZYTEL nylon resin permits a variety of design possibilities. Readily molded to close tolerances, ZYTEL is an excellent material for applications such as the Saxony switch.

For complete information on this versatile material—property tables, typical applications, and production techniques—simply clip and mail this coupon.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 8088, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on Du Pont ZYTEL nylon resin. I am interested in evaluating this material for:

NAME_____ POSITION_____

COMPANY_____

STREET_____

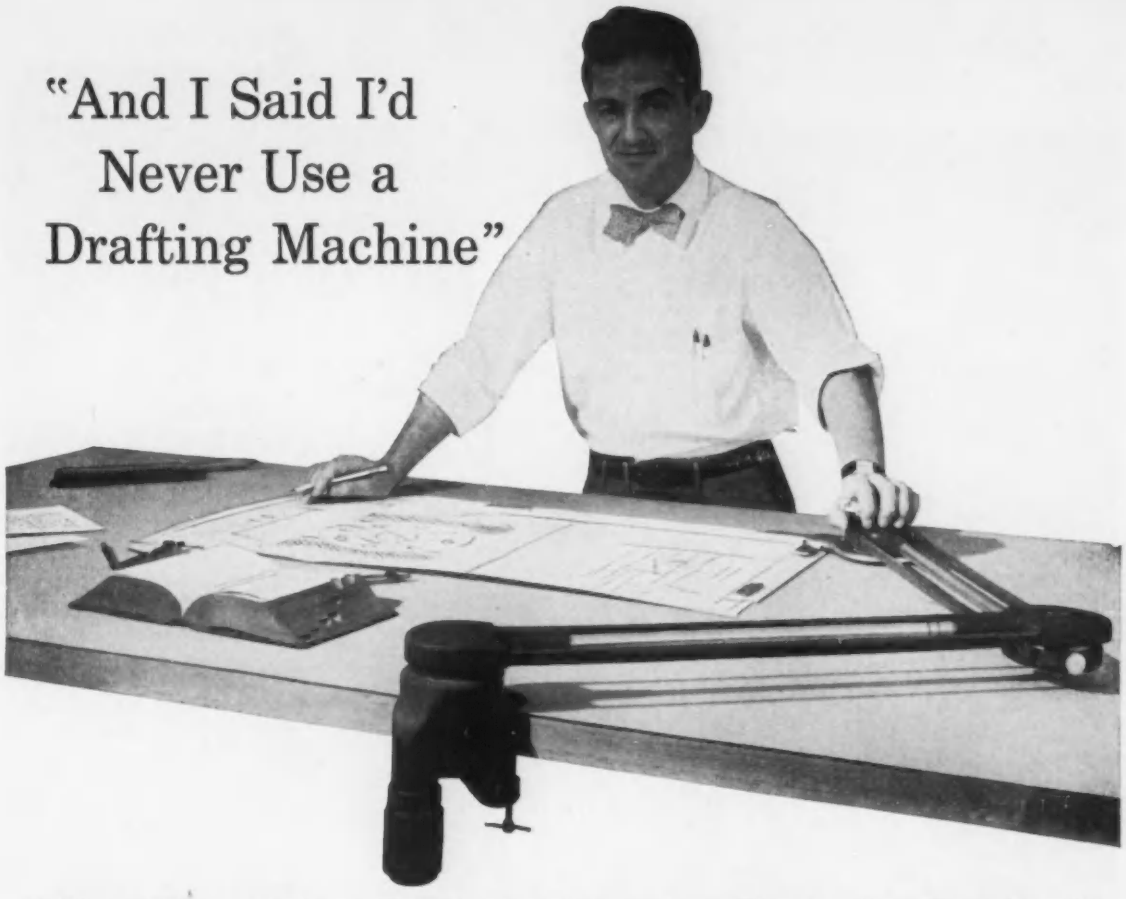
CITY_____ STATE_____

TYPE OF BUSINESS_____

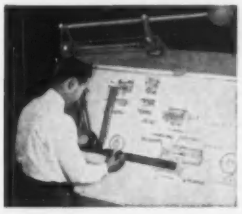
NEED MORE INFORMATION?

Clip the coupon for additional data on the properties and applications of this versatile Du Pont engineering material.

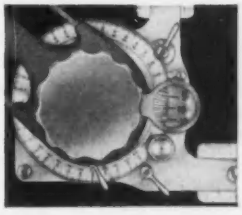
"And I Said I'd Never Use a Drafting Machine"



"That Was Before I Tried a Bruning Equipoise Drafter!"



Bruning Counterbalanced Drafters and Bruning Track Drafters provide fast, easy, accurate drafting on vertical boards and on extra-large drawings.



Bruning Equipoise Drafters are available with either the Civil Engineer protractor head, shown here, with its special azimuth scale, or the Standard protractor head.

Take a tip from an increasing number of draftsmen who, perhaps like yourself, were reluctant to try any drafting machine or had been disappointed in a conventional type drafter. These men now report: Bruning Equipoise Drafters cut drafting time over conventional equipment up to 40% on most jobs, up to 50% on some structural drawings — beat any other drafting machine they ever tried.

But prove it to yourself! See how fast you'll work with one precision instrument combining T-square, straightedge, triangle, protractor, and scales. Feel how the patented Equipoise mechanism eliminates any drift from gravity, literally makes the drafter "float" into place. Find how easy it is to rotate, turn, and lift this drafter — all with the left hand. At the same time, operate the Touch Control button with your left thumb to set the drafter automatically at any of 24 commonly used 15-degree increment angles. Don't overlook the special scale lock that makes it easy to change the scales, holds the scales rigid.

Your own test will convince you of the superiority of a Bruning Equipoise Drafter. Mail coupon today!

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Company_____

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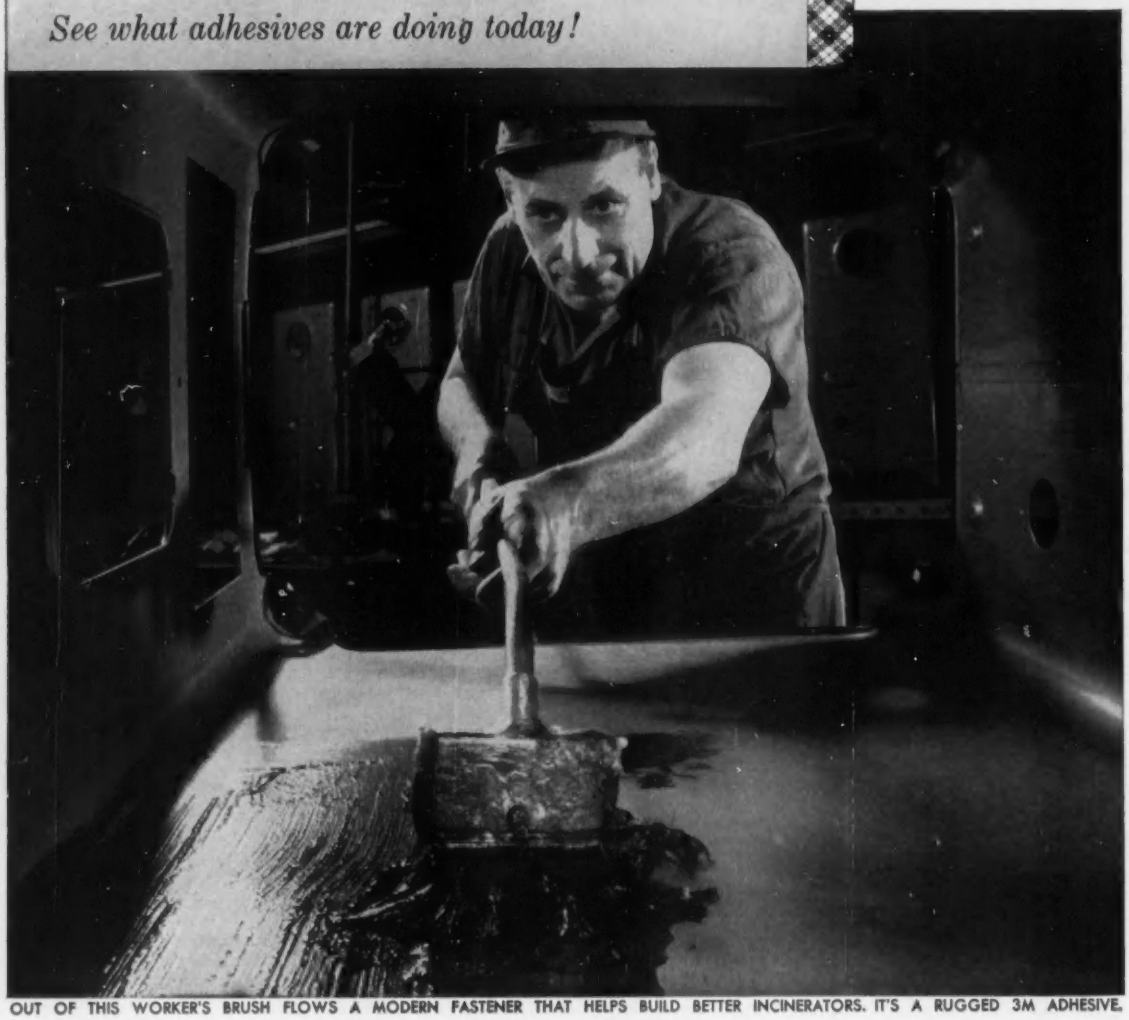
See what adhesives are doing today!



OUT OF THIS WORKER'S BRUSH FLOWS A MODERN FASTENER THAT HELPS BUILD BETTER INCINERATORS. IT'S A RUGGED 3M ADHESIVE.

Setting a tougher trap for heat

It's got to be hot—up to 350°F.—inside this incinerator outer cabinet, so that even *wet* refuse will burn.

To hold the temperature, heat must be kept steadily on the job. A 3M adhesive, EC-321, does it by fastening fibrous glass insulation for keeps inside the cabinet. Trapped, the heat stays hard at work, does the job.

But EC-321 does more than just guard incinerator efficiency. It helps build them more durably, more economically, too. It eliminates the hot spots, weld marks and half the labor of former methods.

Since switching to 3M Brand adhesive, the product engineer hasn't had one complaint of adhesive failure.

Hundreds of other 3M adhesives serve industry in a thousand varied uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

To boost product quality and cut costs, consult 3M research. Contact your 3M Field Engineer. For a free booklet and more information, write: 3M, Dept. 411, 417 Piquette Ave., Detroit 2, Michigan.

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ADHESIVES AND COATINGS DIVISION, **MINNESOTA MINING AND MANUFACTURING COMPANY**

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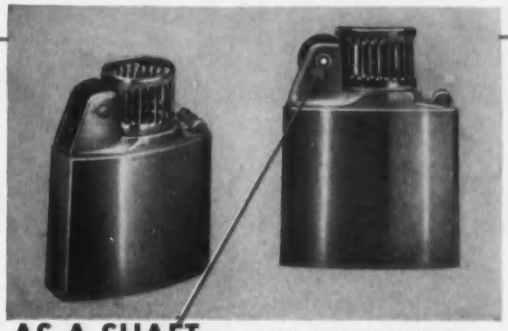
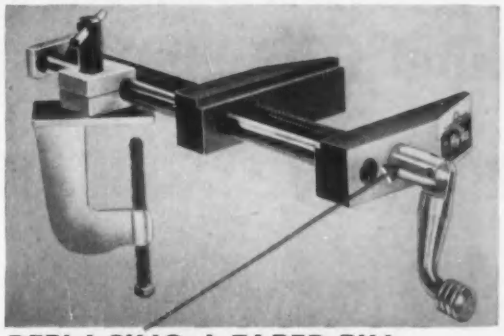
Three typical Rollpin cost reductions

AS A RIVET Rollpin cuts material and assembly costs 25% on Reynolds Gas Regulator Co.'s toggle lever assembly.



AS A SHAFT before and after shot of this Ronson lighter shows how Rollpin made savings of 1½¢ per unit in assembly of spark wheel.



REPLACING A TAPER PIN Rollpin saves 24¢ labor cost on each of American Machine and Foundry's MITY-7-VISES. Eliminates tool cost caused by breakage of small taper reamers.

ESNA TRADE MARK

ROLLPIN TRADEMARK

Where can you use this simple fastener?

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your production and maintenance costs as it does in every class of industry. Rollpin is a slotted tubular steel pin with chamfered ends that drives easily into standard holes, compressing as driven. Its spring action locks it in place—withstanding impact loading, stress reversals and severe vibration. No threading, peening or precision drilling needed. Rollpin is readily removable and can be re-used in the same hole.

ELASTIC STOP NUT CORPORATION OF AMERICA

MAIL COUPON FOR DESIGN INFORMATION

Elastic Stop Nut Corporation of America
Dpt. R38-112, 2330 Vauxhall Road, Union, N. J.

Please send the following fastener information:

☐ **Rollpin samples**

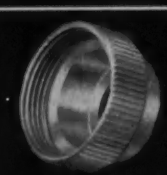
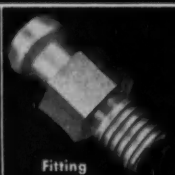
☐ **Rollpin bulletin**

☐ **Here is a drawing of our product. What self-locking fastener would you suggest?**

Name_____ **Title**_____

Firm_____

Street_____ **Zone**____ **State**_____

PART	 Gas Valve Fitting Nut Converted from brass to aluminum	Radio Volume Control Plug Converted from brass to aluminum	Camera Tripod Part Converted from Steel to aluminum	Nozzle Converted from brass to aluminum	 Fitting Converted from brass to aluminum
SAVING (based on 1000 parts)	26.9%	35.0%	38.4%	24.9%	44.0%
INDUSTRY	Gas and oil valves, fittings	Radio and television	Cameras, television, movie equipment	Nozzles, Spray equipment	Heating, Air conditioning

LOOK AGAIN! if you

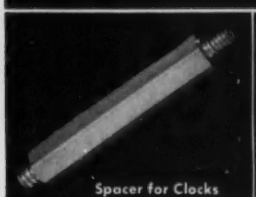
any industry listed here... look again

cost by converting from brass or steel

gives you a unique combination of

match... contact us... let us help

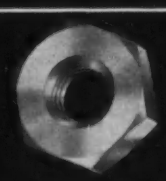
Preferred by Operators | *Specified by Designers* | *Recommended by Management*



Spacer for Clocks
Converted from brass to aluminum

49.0%

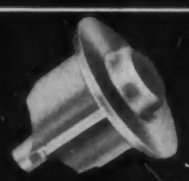
Clocks, electrical equipment, electronics



Aluminum Nuts
Converted from brass to aluminum

38.0%

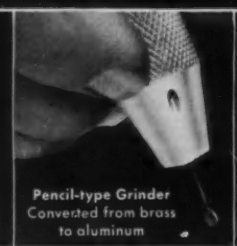
Threaded fasteners



Valve for Hose Coupling
Converted from brass to aluminum

26.0%

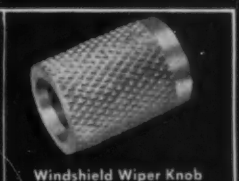
Appliance industries



Pencil-type Grinder
Converted from brass to aluminum

27.0%

Precision Instruments



Windshield Wiper Knob Insert
Converted from brass to aluminum

24.8%

Automotive and Accessories

buy or design screw machine parts for

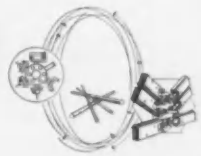
at how you may save up to 49% of

to Kaiser Aluminum . . . plus . . . Aluminum

useful properties no other material can

you estimate your savings in . . .

Kaiser Aluminum



For complete information and expert assistance, call one of our many distributors, or look for our local number in your classified telephone directory.

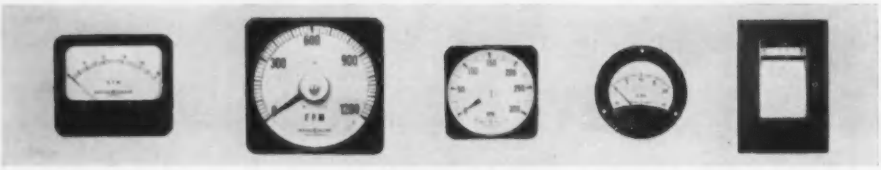
Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.

General Electric Speed Measuring Systems:

Handsome Appearance and Top Quality Increase Customer Acceptance and Resale Value

G-E application engineering and fast shipment help you get the right system when you need it



COMPLETE LINE of indicators and recorders to choose from offers you the exact type speed measurement you require.

General Electric speed measuring systems are offered in a complete line for every application; each system you buy is *tailor-made* to meet your requirements.

Here are 9 reasons why you get optimum performance for your investment with G-E speed measuring systems:

1. Handsome appearance of G-E indicators contributes to the good looks of your product and increases salability.

2. Top quality of every instrument assures you of extreme reliability under severe conditions.

3. High accuracy of ±1% of full scale is made possible by factory calibration of generator and indicator together.

4. Small size of both generators and indicators gives you greater latitude when selecting a mounting position.

5. Excellent readability of indicators is provided by long scales and large numbers. Non-parallax glass of DB-16 and DB-18 indicators allows reading from almost any angle.

6. Totally enclosed, both generators and indicators are fully protected from dust and dirt. Explosion-proof enclosures are available on some models.

7. Fast shipment of complete systems helps you meet commitments.

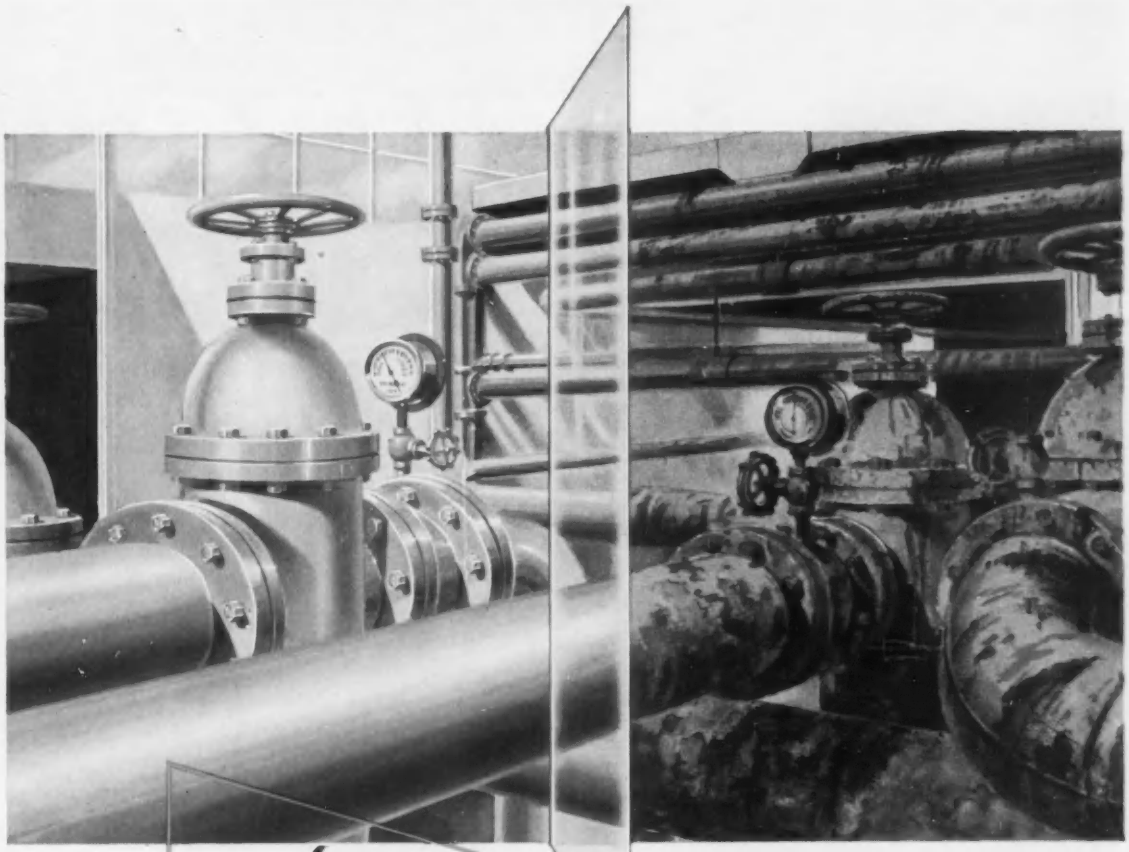
8. G-E application engineering is available to you on request to help you solve your speed measuring problems and select the proper equipment.

9. Any legend you require will be marked on your G-E tachometer indicator scales. Your instruments may be calibrated in units such as feet per minute, inches per minute, spindle rpm or any related speed. Manufacturer's or customer's name may also be imprinted on the scale face.

If you would like additional information on General Electric's complete line of speed measuring systems, call your nearest General Electric Apparatus Sales Office or write for Bulletins GEC-1258 and GEA-6427 to Section 585-57, General Electric Company, Schenectady 5, New York.

EXCEPTIONAL ACCURACY is made possible because generator and indicator are calibrated as a unit at the factory.

GENERAL ELECTRIC



3/32" . . . the difference between long life and lost life!

because it's made of **Firestone**

Corrosion has been sending billions of dollars worth of equipment to the junkyard. Yet in plant after plant, it has been wiped out by thin vinyl linings or coatings.

Made from Firestone EXON 900 Series resin, these linings have minimized corrosion wherever they are used. Mixtures of sulfuric, nitric and hydrofluoric acids . . . concentrations of caustic soda and chlorine . . . have been successfully handled.

Installation is quick, simple, economical. These linings constitute only one of several types of corrosion-fighting-protectives made effective by Firestone EXON research.

For example, dip-coating small and medium-sized parts with plastisol based on EXON 654 resin, produces protection that withstands active corrosives.

Lightweight structural rigids, flues, ducts, and tanks, of EXON 402A have been exposed to virulent acids and alkalies for years without trace of damage.

These are just some of the many resins in industry's most complete line of versatile vinyls. Another reason why industry looks to EXON for engineered answers to its needs.

EXON

VERSATILE VINYL RESINS
engineered answers to industry's needs

Firestone Plastics Company supplies the resins only . . . does not make the coatings or linings.

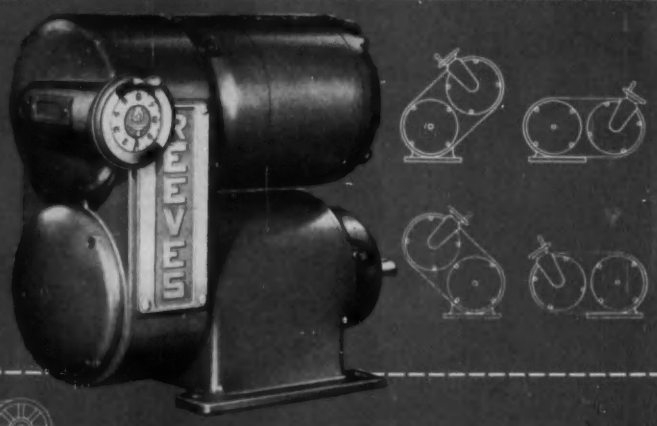
For complete information or technical service on the entire line of Exon resins, call or write today:
CHEMICAL SALES DIVISION
FIRESTONE PLASTICS CO., DEPT. 66P, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

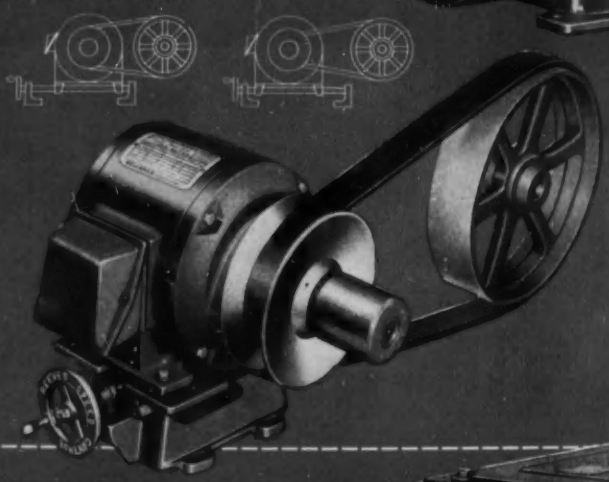
REEVES®

the one name for all mechanical variable speed!

REEVES Vari-Speed® Motodrive

A complete power package . . . choose from over 100 assemblies in vertical, horizontal or 45° models . . . ¼ to 40 hp. . . . 2:1 to 10:1 speed ratios from as low as 3 rpm. to a maximum of 4660 rpm! Assemblies available in standard, totally-enclosed or splash-proof enclosures.





REEVES Vari-Speed® Motor Pulley

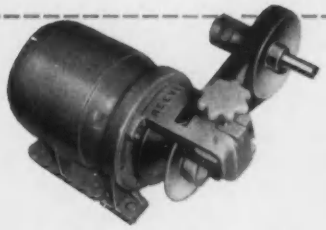
The low cost answer to variable speed advantages! Choose from 8 sizes . . . ¼ to 15 hp. . . . 1.75:1 to 4:1 speed ratio. Easy maintenance and long life assured . . . just 5 main parts. REEVES "close-grooving" lubrication insures free sliding disc for easy speed changes. Standard or countershaft motor bases.

REEVES Variable Speed Transmission

Vertical or horizontal types—in open frames or enclosed cases—straight, countershaft or reducer models. Fractional to 87 hp. . . . 2:1 to 16:1 speed ratios. "Internals only", without frame or case, also available.

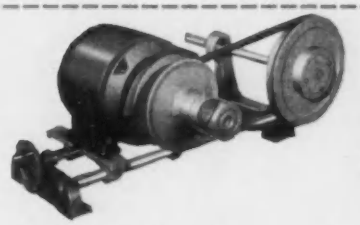
● The *complete line* in the industry is REEVES . . . adjustable speed drives and speed control for applications from ⅛ to 87 hp! The *proven* name is REEVES . . . years of trouble-free service in hundreds of thousands of installations—every industry! The *original* variable speed drive, REEVES is still the leader in its field!

Incorporate variable speed into the machines *you* design: widen the work range of the machines; insure your designs against early obsolescence; add the many operating advantages of accurate, instant speed control. Your REEVES representative—with wide and varied experience—will be glad to work with you for the *best* application . . . *best* results!



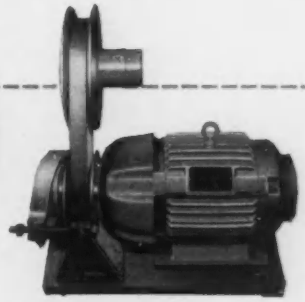
REEVES Flexi-Speed®

Two sets of adjustable discs with convenient shifting mechanism. Provides flexibility, economy to your equipment . . . easy to install. ½, ¾ and 1 hp. with 8:1 speed ratio.



REEVES Jr. Motor Pulley

Simplest form of variable speed control. 5 sizes from ¼ to 1½ hp. capacity . . . ratios up to 2.75:1 in a speed range from 135 to 1965 rpm. Standard or countershaft bases for standard motors.



REEVES Vari-Spin®

A mill tested and proved unit to increase spinning efficiency and frame flexibility. 500 to 1450 rpm. range. Change speeds *with spinning frame in operation* . . . get required speed—in seconds!

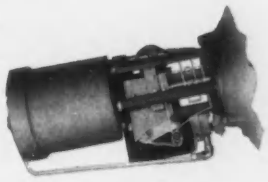
REEVES CONTROLS

Manual

Basic REEVES control on all units. "Speedial" handwheel, extended handwheel, hand chain and extended rod controls also available.

***Mechanical Automatic**

For Motodrive, Transmission. Simplest automatic control—requires shifting force sufficient to position control lever of speed changing mechanism.



Automatic (Pneumatic)

Motodrive application only. Cam-compensated design controls output speeds in direct proportion to instrument air signals.

Electric Remote

Push-button stations for single unit or battery of Motodrives, Transmissions or Motor Pulleys. AC or DC . . . full range of current characteristics.

*Also available in hydraulic or pneumatic type.

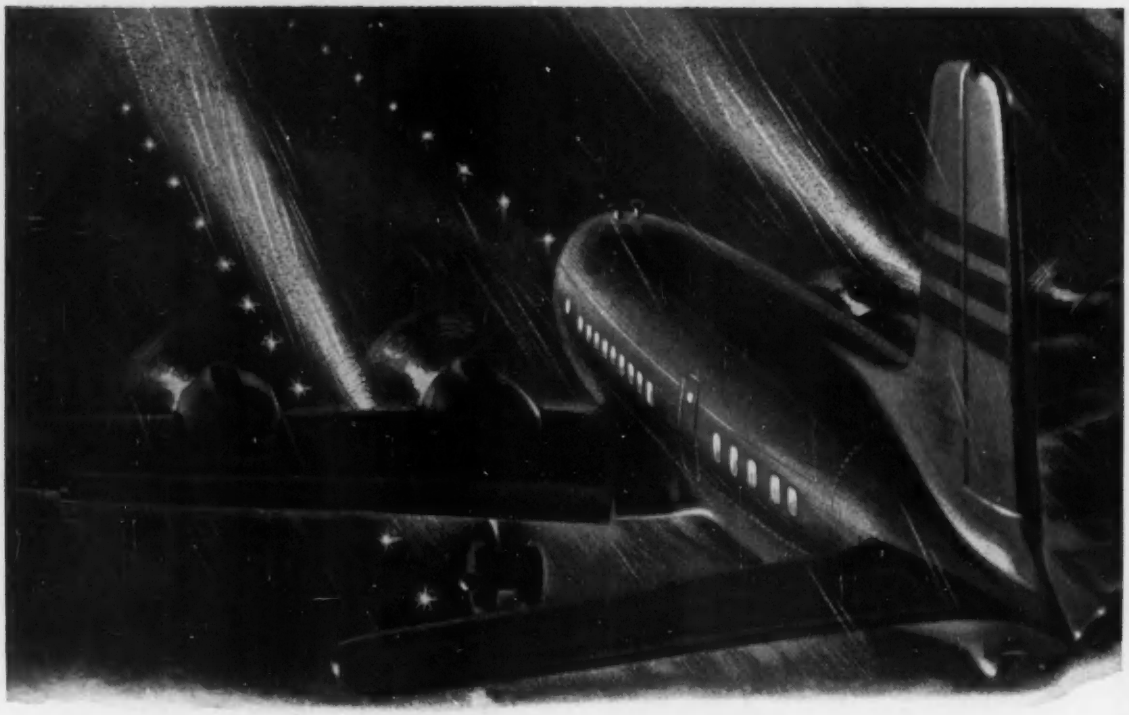
Individual bulletins—complete with rating tables and dimensions—are available for any of the above products by writing REEVES, Dept. K26a, Columbus, Indiana.

Your REEVES representative will be glad to work directly with you. He's as near as your telephone . . . regional offices in 34 principal cities.

REEVES PULLEY COMPANY

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

COLUMBUS, INDIANA



Design Gyro Rotors for Higher Speeds with New Mallory "Gyromet"* Alloy

Mallory "Gyromet" offers outstanding properties

Density	16.70-17.05 gm/cc (.604-.616 lbs./in.^{3})
Endurance limit	55,000 psi
Hardness, Rockwell C	30-36
Coefficient of expansion (25-900°C)	5.88 x 10^6 in/in/°C
Ultimate compressive strength	170,000 psi
Yield strength, compression (0.2% offset)	120,000 psi
Modulus of rupture, torsion	139,000 psi
Modulus of rigidity	19.4 x 10^6 psi
Ultimate tensile strength	
Room temperature	135,000 psi
300° C	98,000 psi
500° C	84,000 psi
Yield strength, tension (0.2% offset)	114,000 psi
Modulus of rupture (flexure)	230,000 psi

*Trademark

Looking for a high density metal for gyro rotors that will withstand rotational speeds *far beyond* those possible today?

Mallory metallurgists, anticipating the requirements of future gyro designers, have developed Mallory 1000 "Gyromet"—a new high density alloy with superior strength and endurance. It's the rotor alloy of tomorrow . . . a powder metal combination of tungsten, nickel, copper and other elements that offers qualities never before possible.

Some of the characteristics of "Gyromet" are listed here, as a guide to your future designs. We invite you to investigate the possibilities this unique material offers for increasing rotor speeds to new higher values . . . for reducing gyro size to new levels of miniaturization.

For current designs, where the exceptional strength of "Gyromet" cannot be fully utilized, Mallory 1000 continues to be the leading high density metal for gyro rotors . . . as well as for counterweights, and for radioactive shielding applications.

Write today for new literature giving complete technical data on Mallory 1000, and Mallory "Gyromet."

In Canada sold by Johnson Matthey & Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

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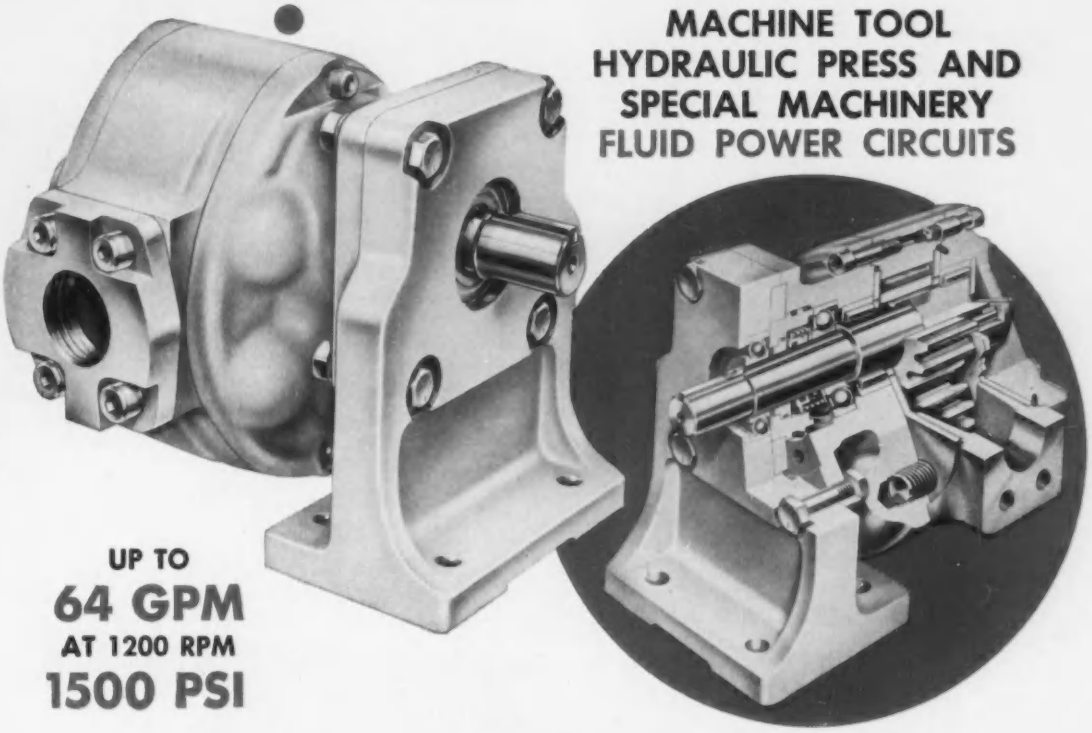
GEAR PUMPS

WITH INDUSTRIAL MOUNTINGS

FOR

MACHINE TOOL
HYDRAULIC PRESS AND
SPECIAL MACHINERY
FLUID POWER CIRCUITS



UP TO
64 GPM
AT 1200 RPM
1500 PSI

HYDRECO Gear Pumps, for years, have been specified as standard Fluid Power equipment by the *big names* in Construction, Earth Moving and Materials Handling Equipment. On these rugged-service applications HYDRECO Gear Pumps perform with outstanding dependability. They will operate under conditions of pressure, temperature, and speed unheard of on the usual industrial application. Mobile Equipment is a highly competitive field and HYDRECO Pumps have always afforded design engineers substantial economies in original equipment costs!

HYDRECO Gear Pumps are now available with standard industrial mountings, port connections and shafts. Builders and users of Machine Tools, Presses, and Industrial Equipment can now profit by the economies in these Pumps.

Make this simple test! If your hydraulic cycle is comparable to that of a tractor-shovel digging a foundation . . . a front-end loader working a gravel pit . . . or, a mammoth bulldozer crowding a bank . . . and working at full relief pressures nearly all the time—then YOU can use HYDRECO Gear Pumps to advantage! HYDRECO Gear Pumps can save YOU money NOW—in both original equipment and replacement costs.

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Write *for performance and installation data on HYDRECO Gear Pumps with Industrial Mountings.*

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Kindly send me full information on HYDRECO Gear Pumps with Industrial Mountings.

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You can build it better

BUILT TO LAST. Light in weight, strong and tough, highly resistant to corrosion and abrasion, the 40-ft. hull of this attractive houseboat, built of 12-ga. USS COR-TEN Steel, has what it takes to give long years of low-maintenance, trouble-free service. Customarily beached by being run right up on the shore, this boat needs COR-TEN Steel's superior strength and high resistance to wear and impact to withstand such rough usage. Says the owner, "Despite the fact that on five different occasions the boat has been dropped from the dry-dock from heights ranging from 6 to 12 feet—treatment that would have completely wrecked a boat of usual construction —the 5½-year-old hull is still in excellent condition and appears good for many, many more years." (This all-steel boat was constructed by Kelly Shop, Inc., Jeffersonville, Ind.)

• • •

USS COR-TEN Steel has been approved by the American Bureau of Shipping for use in hull construction, either riveted or welded, with a general reduction from mild steel weights or sections of about 10 per cent. Lloyds Register of Shipping has stated that COR-TEN Steel is acceptable under its rules as a special quality steel for ship building. Its use in oil tankers, ore boats, dredges, barges and pleasure craft, both in fresh and salt water service during the past 23 years, has definitely proved USS COR-TEN Steel's exceptional fitness for marine construction.

with USS High Strength Steels

In USS High Strength Steels, design engineers have at their command three service-tested steels that will permit them to materially increase the efficiency and economy of machinery, equipment and structures at little or no increase in first cost . . . and frequently at less cost.

All three of these famous *"steels that do more"*—USS Cor-Ten, USS Man-Ten and USS Tri-Ten "E"—have a 50% higher yield point than plain carbon steel. All have better atmospheric corrosion resistance and offer greater resistance to wear, fatigue and impact. Each, however, has specific superior properties that should be considered in determining its selection.

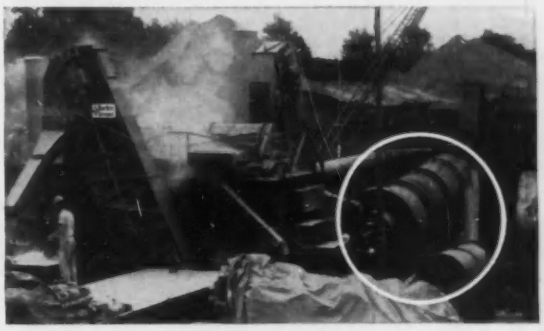
USS Cor-Ten Steel, for example, is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel. USS Man-Ten Steel is intended for weight reduction by means of greater strength in moderate forming applications, with enhanced resistance to abrasion and atmospheric corrosion. USS Tri-Ten "E" Steel's outstanding characteristics are excellent weldability and resistance to shock.

Used singly or in combination, these steels can advantageously replace carbon steel to increase the strength and durability of vital parts *without* increasing their weight. Or when the use of thinner sections is feasible, they can (1) reduce equipment weight without reducing its strength, or (2) increase the size and capacity of equipment without increasing total weight or the power required to move it.

• • •

You will find our 174-page *"Design Manual for High Strength Steels"* extremely useful in applying the benefits of these steels to your product. Send for free copy—simply write on your company letterhead to United States Steel Corporation, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

"PREGNANT PLATYPUS." That's what the designers call this new combination trailer made to carry two completely unrelated types of products. Going in one direction it hauls 800 gals. of glue in the "dromedary" tank and 4,000 gals. in the belly tank below the trailer. On the return trip it carries 42,000 lbs. of plywood in the trailer van. To reduce empty weight and obtain greater strength—and at the same time to provide resistance to the mildly corrosive glue carried—USS Cor-Ten Steel was used in both tanks and in the trailer frame, body framing and cross frame members as well. As a result, the unit weighs 1,800 lbs. (11½%) *less* than if mild steel had been used, and will carry maximum payload, require less maintenance and last longer. Built by Peerless Trailer and Truck Service, Portland, Ore., for M and M Wood Working Company.



TO BEAT HEAT AND ABRASION. This asphalt mixing plant produces tar or asphalt road-paving mixes at a rate of more than 60 tons per hour. In the dryer, which removes the moisture from the sand and stone in the aggregate, temperatures run as high as 800° F. Abrasive action is severe.

To meet these conditions the Barber-Greene Co. of Aurora, Ill., builds the entire dryer drum (circle) of USS Man-Ten Steel. In this way they obtain one and a half times greater yield point than with carbon steel, greater abrasion resistance, and greater resistance to heat, impact and vibration. These qualities pay off by keeping the equipment more continuously on the job.

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USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL

UNITED STATES STEEL USS HIGH STRENGTH STEELS 1933 1956 23 YEARS OF PERFORMANCE

Master B-100 Portable Space Heater
MANUFACTURED BY MASTER VIBRATOR COMPANY DAYTON, OHIO

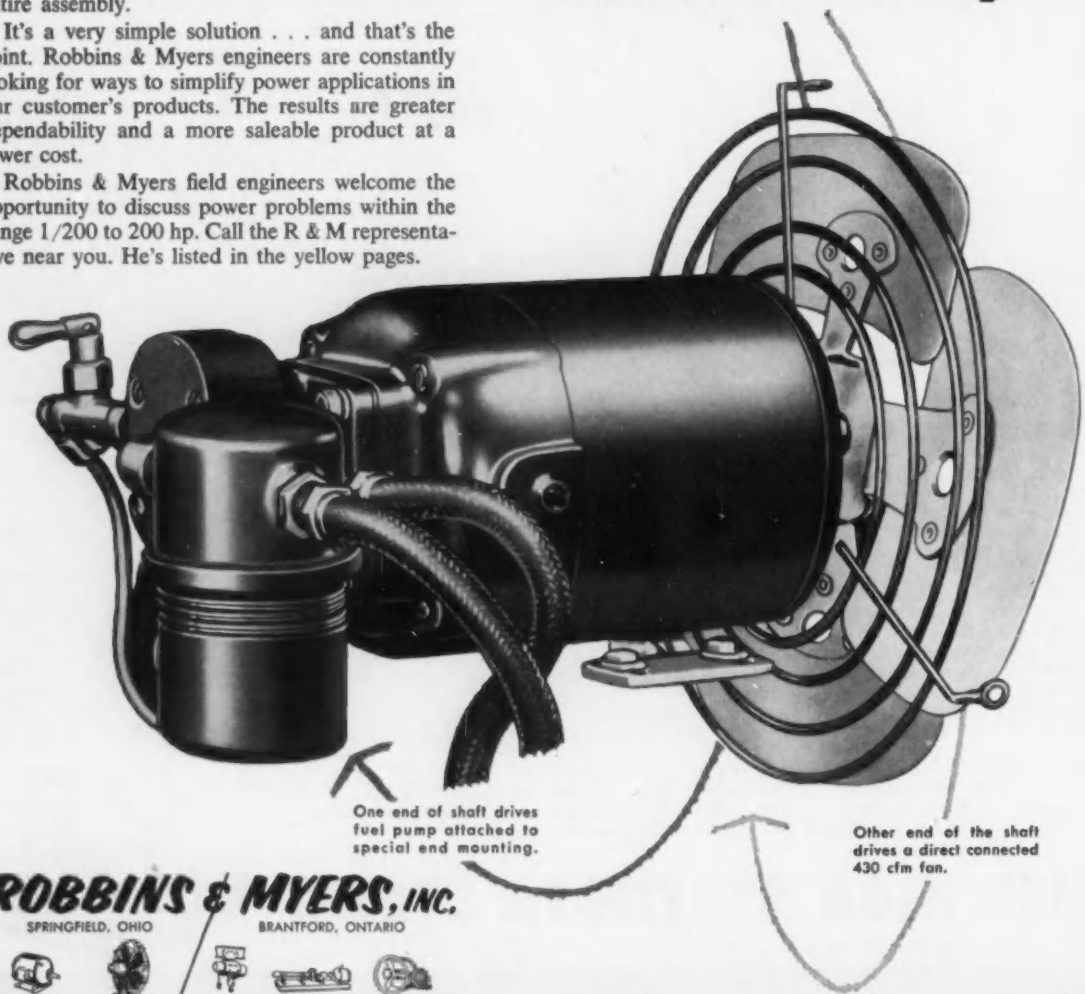
R&M motor does double duty

To accomplish compactness, simplicity and lower cost, this enclosed ¼ hp., 3450 rpm split phase Robbins & Myers motor was specially designed to do two important jobs in the Master B-100 Portable Space Heater.

A special face mounting accommodates a direct driven fuel pump. The other end of the shaft drives a direct connected fan with an output of 430 cfm. A rigid foot mounting on the motor supports the entire assembly.

It's a very simple solution . . . and that's the point. Robbins & Myers engineers are constantly looking for ways to simplify power applications in our customer's products. The results are greater dependability and a more saleable product at a lower cost.

Robbins & Myers field engineers welcome the opportunity to discuss power problems within the range 1/200 to 200 hp. Call the R & M representative near you. He's listed in the yellow pages.


One end of shaft drives fuel pump attached to special end mounting.
Other end of the shaft drives a direct connected 430 cfm fan.

ROBBINS & MYERS, INC.
SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

45 years OF SERVICE TO INDUSTRY

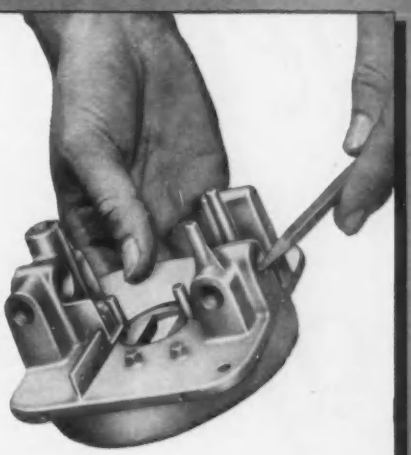
This job was a "Toughie"

—but its price tag didn't show it!

Considering the complex problems presented by this die casting, you'd probably overestimate its actual cost.

The job called for an internally-cast jar thread and a great deal of precision machining which all added up to a tall order. Yet Stewart, with its experience and complete machining facilities, not only "delivered the goods," but produced the unusual casting in volume – economically!

Call on Stewart the next time you need a die casting. Then you will know that your most rigid specifications will be met – *and on time!*



This emblem is your assurance that the zinc alloy used in every Stewart die casting meets the rigid specifications established by the American Die Casting Institute.

Stewart DIE CASTING

A DIVISION OF STEWART-WARNER CORPORATION

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Manganese helps ease the squeeze on Stainless Steel!

Important facts about a new and plentiful family of low-nickel Stainless Steels!

Now in plentiful supply, the new "200" Series Stainless Steels permit steelmakers to greatly expand their output of Chrome-Nickel stainless from existing nickel supplies. With the addition of manganese, the nickel content can be cut in half to provide practical, workable stainless steels that can be applied to a wide variety of uses.

The "200" Series is meeting the constantly expanding needs of the transportation, building, manufacturing and many other fields. It's becoming increasingly popular for use in kitchen utensils, appliances, truck bodies, trains, automobile trim, hospital equipment and scores of other consumer products.

For further information, see your stainless steel supplier, or write ELECTROMET—leading producer of chromium, manganese, and more than 100 alloys for the steel and other metal industries.

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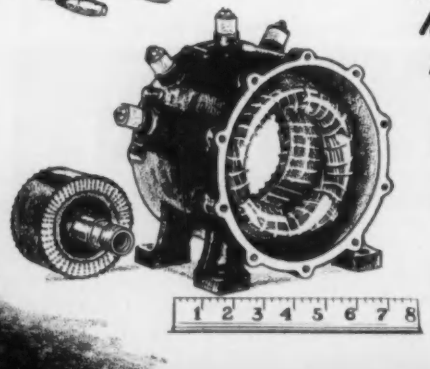
DESIGN SOLUTIONS with G-E

NOW, SHADED-POLE FAN MOTORS USED ON MANY LABOR-SAVING DEVICES SUCH AS GLASS WASHERS, SHOE BUFFERS, BUTTER CHURNS

SHADED-POLE MOTORS--LONG KNOWN AS **SMALL, LOW COST** MOTORS FOR FAN AND BLOWER APPLICATIONS--ARE NOW USED IN A MYRIAD OF ADDITIONAL APPLICATIONS. GENERAL ELECTRIC **PERMANENTLY-LUBRICATED** SHADED-POLE MOTORS HAVE MANY FEATURES WHICH MAKE THEM DESIRABLE--**SUPERIOR VENTILATION--MOUNTING FLEXIBILITY--SMALLER DESIGN--ALL-ANGLE OPERATION**--CHOICE OF OPEN, TOTALLY ENCLOSED OR TOTALLY ENCLOSED FAN-COOLED MODELS--RATINGS 1.5 WATTS- 1/4 HP. TYPICAL APPLICATIONS ARE ELECTRIC SHOE BUFFERS FOR THE HOME AND OFFICE--BUTTER CHURNS--DISH AND GLASS WASHERS IN RESTAURANTS--SANDERS--AQUARIUM AIR AND WATER PUMPS--SUMP PUMPS--AND MANY OTHERS.

AIRLINERS COOLED BY HERMETIC MOTOR PARTS LESS THAN 6½ INCHES IN DIAMETER--25 HP DELIVERED CONTINUOUSLY AT 23,500 RPM.



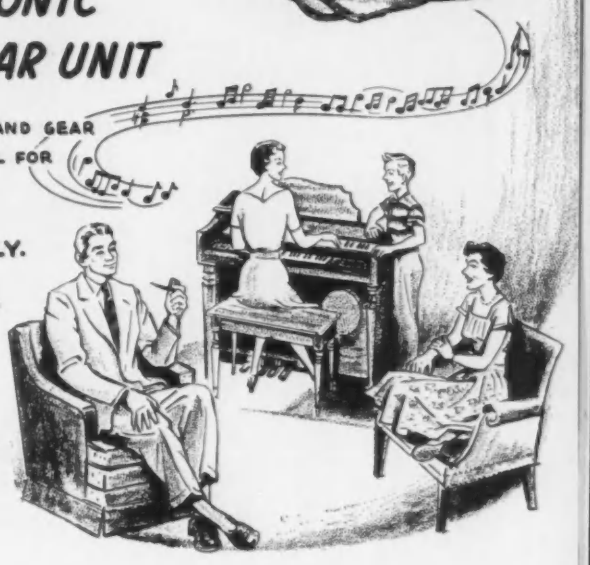
HERMETIC MOTOR PARTS WITH **DIAMETER OF ONLY 6 5/16 INCHES WEIGH ONLY 18 POUNDS**--YET DELIVER 25 HP CONTINUOUSLY AT A SPEED OF 23,500 RPM!

DESIGNED TO POWER AN AIRBORNE COMPRESSOR, THESE PARTS-STATOR, ROTOR AND SHELL-ARE COOLED BY FREON CIRCULATING THROUGH THE SEALED PARTS. THE COMPACT TWO-POLE, 400-CYCLE CONSTRUCTION MAKES POSSIBLE A CONTINUOUS 25 HP RATING.

specialty motors

QUIET, COOL-RUNNING G-E 1/20 HP MOTOR VIBRATES ELECTRONIC ORGAN REEDS; ELIMINATES GEAR UNIT

ORIGINALLY, WURLITZER CO. ENGINEERS USED A MOTOR AND GEAR IN A SOUNDPROOF HOUSING TO POWER A BLOWER WHEEL FOR VIBRATING ORGAN REEDS. BUT BY SWITCHING TO A G-E 3450-RPM 1/20 HP SMALL INDUCTION MOTOR, THEY WERE ABLE TO **ELIMINATE THE GEAR UNIT ENTIRELY.** ALSO, THE EXTREME QUIETNESS OF THE COMPACT LITTLE MOTOR ENABLED THE ORGAN DESIGNER TO MOUNT THE MOTOR OUTSIDE OF THE SOUNDPROOF HOUSING!

AFTER THE MOTOR-POWERED BLOWER STARTS REEDS VIBRATING, THE ORGANIST TOUCHES KEYS AND A METALLIC PICK-UP ARM FEEDS VIBRATIONS INTO AN ELECTRONIC SYSTEM TO THE AMPLIFIER. THE RESULT: **SOFT ELECTRONIC MUSIC WITH THE HELP OF A G-E MOTOR!**

AVAILABLE: COMPLETE FHP MOTOR ENGINEERING ASSISTANCE FOR YOU!

HERE'S THE SPECIAL ATTENTION YOUR SMALL-MOTOR PROBLEMS GET AT G.E.

1 YOUR LOCAL G-E APPARATUS SALES ENGINEER LEARNS ALL ABOUT YOUR MOTOR NEEDS

2 HE CALLS A TEAM OF FACTORY ENGINEERS WITH YEARS OF MOTOR APPLICATION EXPERIENCE

3 AT THEIR DISPOSAL ARE G.E.'S COMPLETE DEVELOPMENT AND TESTING FACILITIES

4 IN SHORT ORDER A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCT

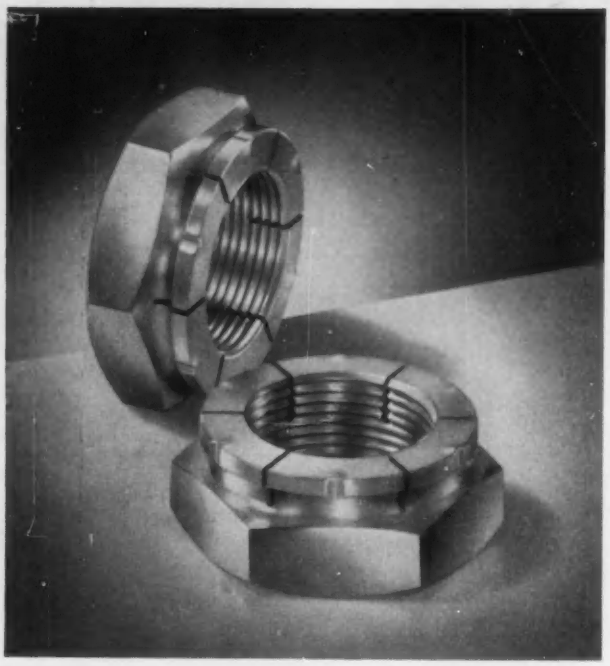
FOR THIS COMPLETE HELP, CONTACT YOUR NEARBY G-E APPARATUS SALES OFFICE TODAY.

WRITE FOR FREE BULLETINS COVERING G-E EQUIPMENT DESCRIBED IN THIS AD TO GENERAL ELECTRIC CO., SECT. 632-6, SCHENECTADY 5, N.Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Flexloc thin nuts save space, weight and production time



Self-locking nuts are 30% lower and lighter; speed up assembly with hand or power tools

Self-locking FLEXLOC thin nuts are 30% lower than regular height locknuts of the same nominal diameter. They fit into spaces where regular height locknuts will not go. You can design lighter, more compact units with them.

Where you must reduce weight in a completed assembly, you can save by using shorter bolts with these lighter nuts. And you save production time. The length of engagement of mating threads is shorter: fewer revolutions of hand wrenches or power nut runners are needed to seat them.

FLEXLOC nuts are of 1-piece, all-metal construction. You can use a FLEXLOC fully seated as a locknut or at any point along a bolt as a stop nut. Once the threads in the resilient locking section are fully engaged, the FLEXLOC grips the mating threads with uniform locking torque wherever wrenching stops. Since there are no nonmetallic inserts to come out or deteriorate, the locking life of a FLEXLOC is virtually unlimited.

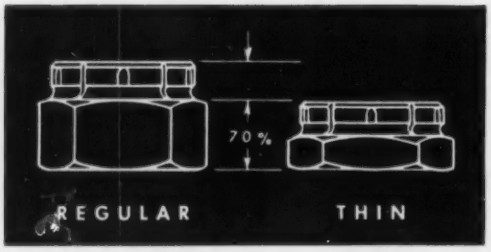
Your authorized industrial distributor stocks FLEXLOC nuts in a variety of sizes, materials and finishes. Consult him for details. Or write us for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

SPECIFICATIONS
FLEXLOC THIN NUTS

NATIONAL COARSE THREAD—U.S.S

SIZE	A INCHES	H INCHES	WIDTH ACROSS CORNERS	WEIGHT PER 1000 NUTS
6-32	.312	.125	.361	1.8
8-32	.344	.172	.397	2.8
10-24	.375	.172	.433	3.3
¼-20	.438	.203	.505	5.4
5/16-18	.563	.250	.649	11.6
⅜-16	.625	.265	.722	14.9
7/16-14	.750	.312	.866	24.9
½-13	.813	.312	.938	28.4
9/16-12	.875	.359	1.010	36.1
⅝-11	1.000	.391	1.155	54.1
¾-10	1.125	.406	1.299	69.2
⅞-9	1.312	.469	1.516	107.5
1-8	1.500	.563	1.732	171.6
NATIONAL FINE THREAD—S.A.E.				
6-40	.312	.125	.361	1.8
8-36	.344	.172	.397	2.8
10-32	.375	.172	.433	3.3
¼-28	.438	.203	.505	5.4
5/16-24	.500	.250	.577	8.7
⅜-24	.563	.266	.649	11.5
7/16-20	.625	.312	.722	14.9
½-20	.750	.312	.866	21.7
9/16-18	.875	.359	1.010	36.2
⅝-18	.938	.391	1.082	42.4
¾-16	1.063	.406	1.227	54.5
⅞-14	1.250	.469	1.443	84.6
1-14	1.438	.563	1.660	136.3
1 1/16-12*	1.625	.625	1.876	193.5
1 1/4-12*	1.813	.750	2.093	296.0
1 3/8-12*	2.000	.812	2.309	389.0
1 1/2-12*	2.187	.875	2.526	498.0

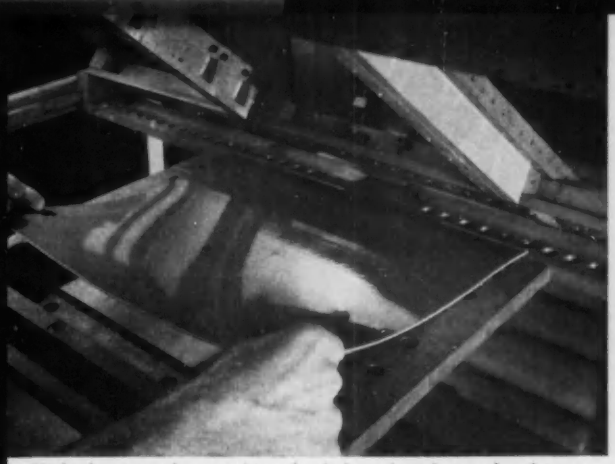
*Steel only (plain or cadmium plated) in stock sizes.



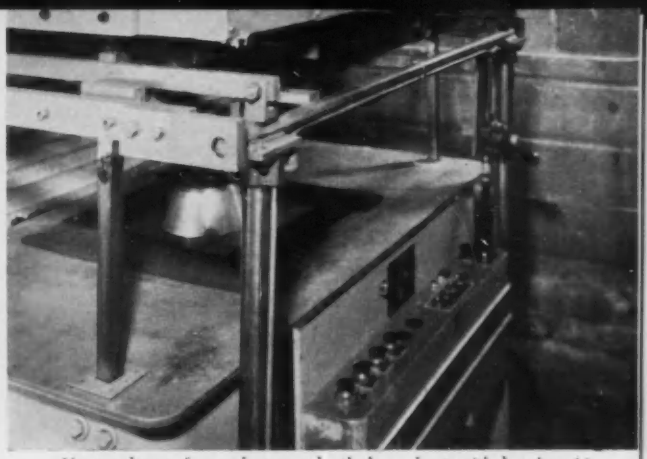
FLEXLOC thin nuts are 30% lower than regular height locknuts. There is a corresponding saving in weight. In sizes through 5/16 in., thin FLEXLOCs meet tensile strength requirements for regular height locknuts. FLEXLOC nuts can be made in the thin type because every thread, even those in the locking section, carries its full share of the load. There are no nonmetallic inserts to waste head space or weaken the structure of the nut.

Standard FLEXLOC self-locking thin nuts are available in plain or cadmium plated alloy steel, for use in temperatures to 550°F; in plain or silver plated corrosion resisting steel, for temperatures to 750°F; and in brass and aluminum, for temperatures to 250°F.

STANDARD PRESSED STEEL CO.
FLEXLOC LOCKNUT DIVISION SPS
JENKINTOWN PENNSYLVANIA



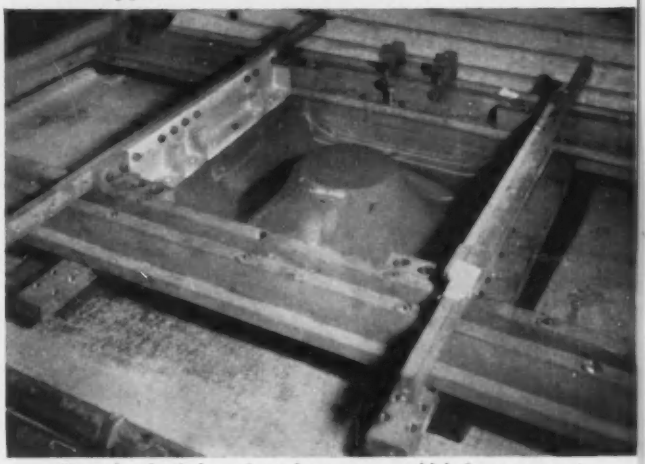
High gloss is evident on this polyethylene sheet being placed in clamping frame just prior to vacuum-forming.



Heater drawn forward over polyethylene sheet with bowl mold in position. Low mold cost is one advantage of the vacuum-forming process.

Partial list of properties of BAKELITE Polyethylene DFD-4030, based on laboratory tests:

Specific Gravity (D792-50 Method A)	0.92
Melt Index (D1238-52T)	1.7-2.4
Tensile Strength (D412-51T), psi	1800
Per Cent Elongation (D412-51T)	550
Brittle Temperature (D746-55T), 80% non-failure, deg. C.	-80
Stiffness Modulus (Torsion) at 23 deg. C. (D1043-51)	22,000
Durometer Hardness (D676-49T)	40 at 75 deg. F., 28 at 140 deg. F.
Coloring Properties	Unlimited



Heated polyethylene sheet drapes over mold before vacuum is applied. DFD-4030 is readily deep-drawn to large-size sections.

Now . . . Design for

The performance features of polyethylene, the production economy of vacuum-forming

Here is a new development from the laboratories of Bakelite Company, major supplier of the leading extrusion plastics for vacuum-forming. BAKELITE Brand Polyethylene DFD-4030 is especially compounded for the process. Your product can now enjoy all the well-known advantages of polyethylene in addition to fast, economical fabrication.

Vacuum-forming has gained wide acceptance because of its speed and low cost, *particularly for large-size sections*. The simplicity of the process is evident from the pictures on this page, taken at Bakelite Company's extrusion laboratory, where BAKELITE Polyethylene DFD-4030 is carefully evaluated for optimum performance under vacuum-forming.

Now, the many advantages of polyethylene—light weight, chemical resistance, dielectric strength, color—are available to products vacuum-formed from DFD-4030. The table above gives some of its performance properties. For more details, consult your plastics fabricator or write Dept. VC-145.

BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

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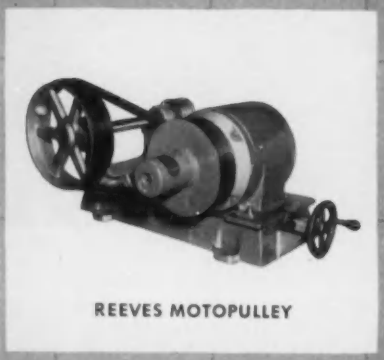

● WIDENING THE HORIZONS OF

Automation is the key to greater production of more goods and services at lower cost. The Tools of Automation can be applied profitably in a countless number of individual industries.

Reliance can provide *you* with valuable engineering assistance which can help secure the advantages of automation.

Our Tools of Automation consist of electric motors, variable-speed drives and controls.

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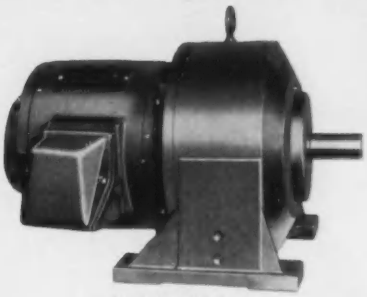
TOTALLY-PROTECTED MOTORS

REEVES MOTODRIVE



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RELIANCE MOTORS ON HIGH SPEED AUTOMATIC TRANSFER MACHINES

AUTOMATION

Application of these tools ranges from a single motor to multi-motor drives for highly complex production lines, where materials are processed into finished products in one continuous operation.

The world's largest manufacturer devoted exclusively to the production of quality motors and drives is ready to help you widen the horizons of automation in your plant.

Bulletin No. A-1555-B gives further details.

A-1519

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1. Choice of mounting — Complete line permits *six* different mounting methods — makes your design job easier.

2. Choice of sealing — Depending on your requirements, you can specify mechanical seals (if clear liquids are pumped), or sealless construction (where gritty and abrasive particles are in liquid).

3. Choice of impeller — Single-suction impellers are available in either enclosed or open design—double-suction, open design.

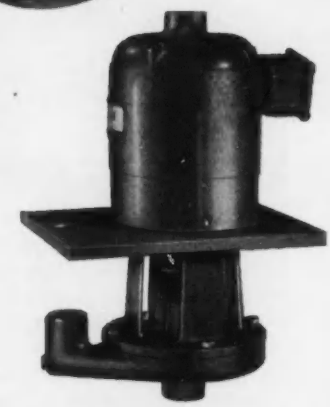
Pump Experts from Allis-Chalmers can help you with your application. Contact your nearby A-C sales office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

MOUNTED ON DRILLING MACHINE, this A-C pump is sidewall mounted, is sealless, and has open impeller.

AVAILABLE in fractional horsepower and integral sizes, above model is designed for mounting on vertical surface.

VERTICALLY MOUNTED on liquid reservoir, this design operates efficiently with varying liquid levels. Available in four optional discharge positions.

SUBMERGED MOUNTED, this type of pump is frequently used on machines requiring mounting in coolant tank.



SHALLOW SUMP or reservoir use is ideal for this submerged mounted model featuring a sealless design.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

A-5201

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And these thousands of assemblies from the modern Wilco plant are your assurance that you can profit from the quality and economy that only volume production can give you.

For the H. A. Wilson Co. is a specialist in contacts and thermometals ...and in the unique skill necessary to combine the two for maximum performance. Yes, it's smart to do business with a specialist.

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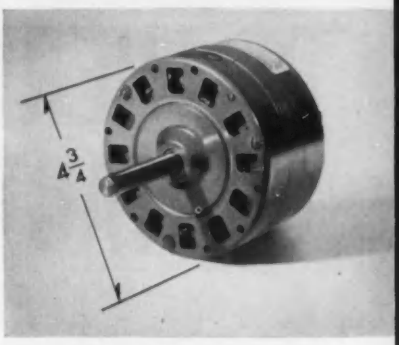
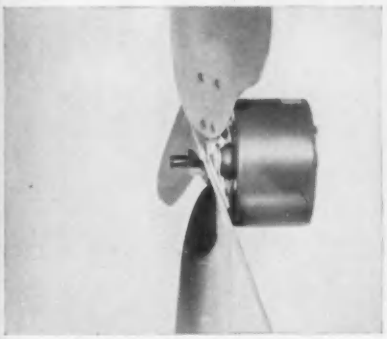


SMALLER DIAMETER and shorter length of this new motor make it possible to design compact, better looking, more salable products. Also speed installation, cut shipping costs and stocking space requirements.



MOUNTING CONVENIENCE—choice of either flush mounting with extended through-bolts (2, 3, or 4) or resilient mounting—helps solve design problems. Bearing construction permits all-angle operation.

PRECISION BRACKETS of heavy-gauge, drawn steel reduce motor length . . . provide quieter operation and longer life. Flat, circular area around through-bolts makes flush mounting possible—much easier.

NEW LUBRICATION SYSTEM with larger oil capacity circulates oil through filtering wicks . . . assures positive oil film between bearings and shaft plus quieter, cleaner, cooler—more economical—operation.

New motor goes on a diet to help streamline your products

More compact Westinghouse shaded-pole motor designed for today's modern air-moving equipment

Here, in a compact package smaller in diameter than conventional designs and no longer than a cigarette, Westinghouse has combined these benefits for you—lower costs, easier installation, minimum air-movement restriction, and longer, trouble-free operation.

Whatever your product—room air conditioners, ventilating fans, unit heaters and coolers, furnace blowers or the like—you will find new opportunities to cut costs, streamline your product and increase its salability with a new Westinghouse shaded-pole motor.

For more information on the new Westinghouse shaded-pole or permanent split-capacitor motors, contact your nearby Westinghouse sales office. Or, write Westinghouse Electric Corporation, Small Motor Division, P. O. Box 566, Lima, Ohio. J-03031-X

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***

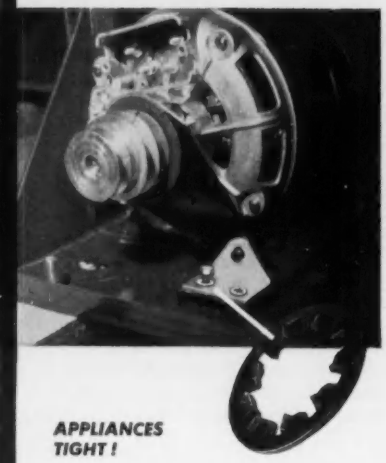
Everlock lock fasteners

AUTOMOBILES TIGHT!

Fast-handling Everlock Sems with combination internal-external lock washers proved the perfect answer for this intake air filter fastening . . . one of many automotive applications.

ELECTRICAL EQUIPMENT TIGHT!

Everlock external and internal lock washers enable this temperature control to laugh at vibration. Any product that must be tight to be right needs Everlock.

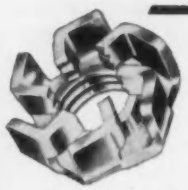


APPLIANCES TIGHT!

This motor will never loosen thanks to Everlock internal lock washer's 2-way bite. Vibration actually makes these amazing fasteners grip tighter.

2-way bite locks assemblies tight

Everlock Sems



Everlock Lock Nuts

Everlock Lock Washers

Everlock Terminals

Another AMF Product
Everlock
INDUSTRIAL FASTENERS

Nothing else holds like an Everlock lock fastener. Each angled tooth has two chisel edges, one bites deep into the work the other into the screw. And Everlock's teeth are *precision set*. The *entire edge surface* — not just the point — bites in, top and bottom, to give an unbreakable hold. Vibration, constant jarring and impact actually *tighten* Everlock's bulldog bite.

For the best in fast-handling Sems, lock washers, lock nuts and terminals, *your* specs should say Everlock. Fast delivery on all sizes, types and finishes.

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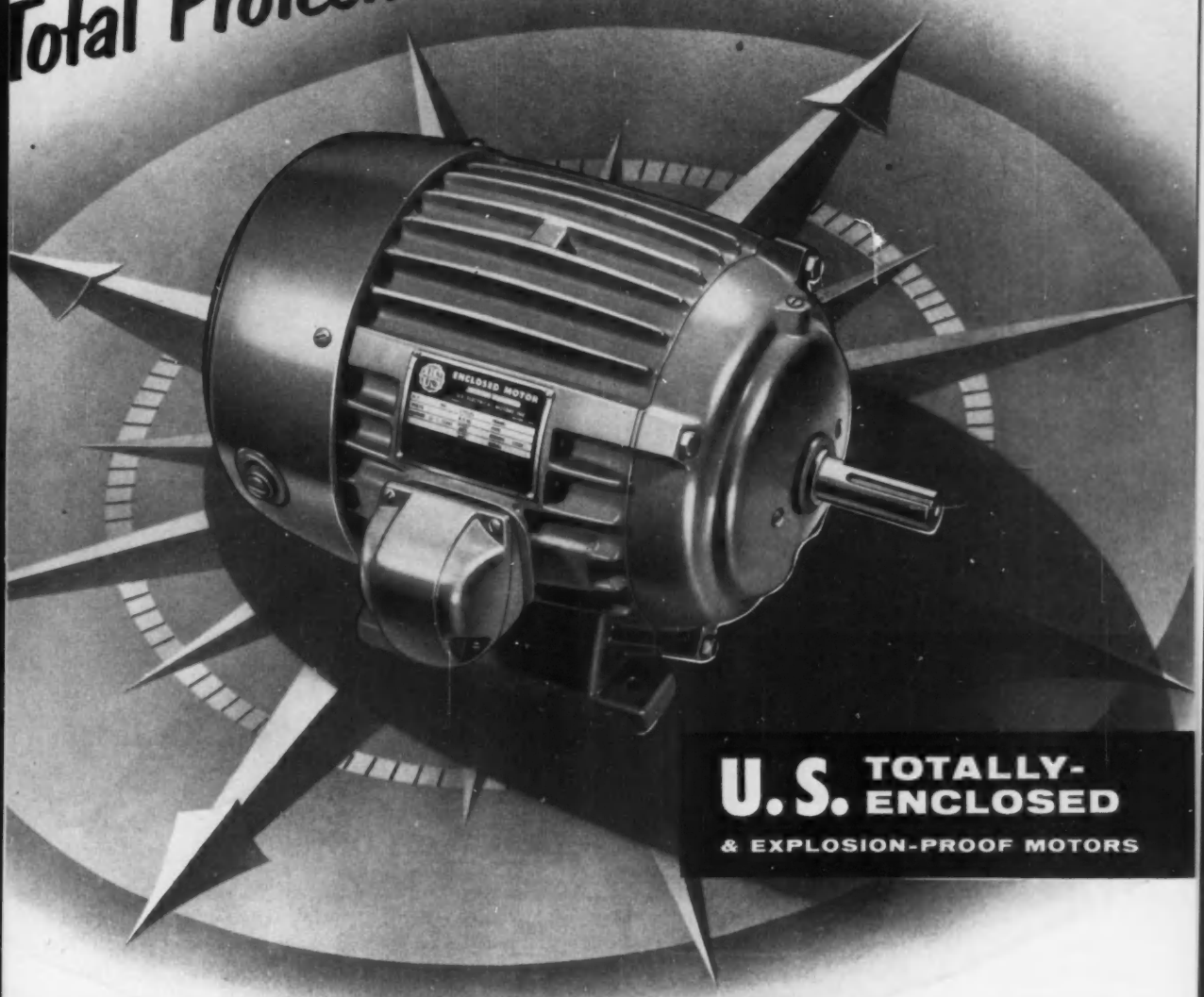
Total Protection...in Every Direction



U. S. TOTALLY-ENCLOSED
& EXPLOSION-PROOF MOTORS

Protected AGAINST EROSIVE POLLUTION...

...U. S. Totally-Enclosed and Explosion-Proof Motors provide all-around protection against corrosion, weather exposure, bad contaminants, caustic conditions, dust and erosive elements. All types are NEMA-dimensioned.

Protected AGAINST INTERNAL HEAT...

Asbestos protected windings, cooling ribs, and a heavy duty fan form outstanding features to give U. S. Totally-Enclosed motors maximum protection against heat.

Protected AGAINST BEARING FAILURE...

Lubriflush transverse re-Lubrication is possible without disassembly of motor or fan guard. Grease fittings are outside. Lubriflush forces out old grease and injects new lubricant around and through the bearings.

Protected AGAINST SHOCK AND VIBRATION

...The hefty cast-iron frame of the U. S. Totally-Enclosed motor is normalized to provide a non-stress, single-piece structure. Rugged feet are integrally cast with the frame; not welded on.

U.S. MOTORS — U.S. Electrical MOTORS

U. S. ELECTRICAL MOTORS Inc. PEN-11
P. O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.
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The drafting stage—not later—is the time to design-in oil seals!

Oil seals are precision products. They are designed to operate under a specific set of conditions. Change just one of those conditions—lubricant, shaft speed, temperature, even bearing position—and a different seal will almost always be needed.

Why chance costly retooling or remanufacture? Specify the correct seal on the drawing-board. And when you do, get all the information there is on new seals, new lip compounds, and mechanical designs. Get it from your National Oil Seal Engineer. His counsel is complete, up-to-the-minute, and accurate. You couldn't buy better oil seal information, yet his help is yours for the asking.

Why "do it yourself?" Call the nearest National Oil Seal Engineer now.

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DIVISION, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
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Have you been bogged down with paper work lately, thereby missing a chance to save money by streamlining your wire buying?

Your American Steel & Wire representative can be of immense help if you give him a call. For example, he may be able to suggest more economical buying units or packaging specifications, or find one type of wire that will do the job of two. Turn him loose in the plant, because he might find a lower cost way of doing the job —with a better product the result.

At AS&W, we *use* a lot of wire in our own plants, and have learned many little tricks that are yours for the asking. Just call your American Steel & Wire representative.

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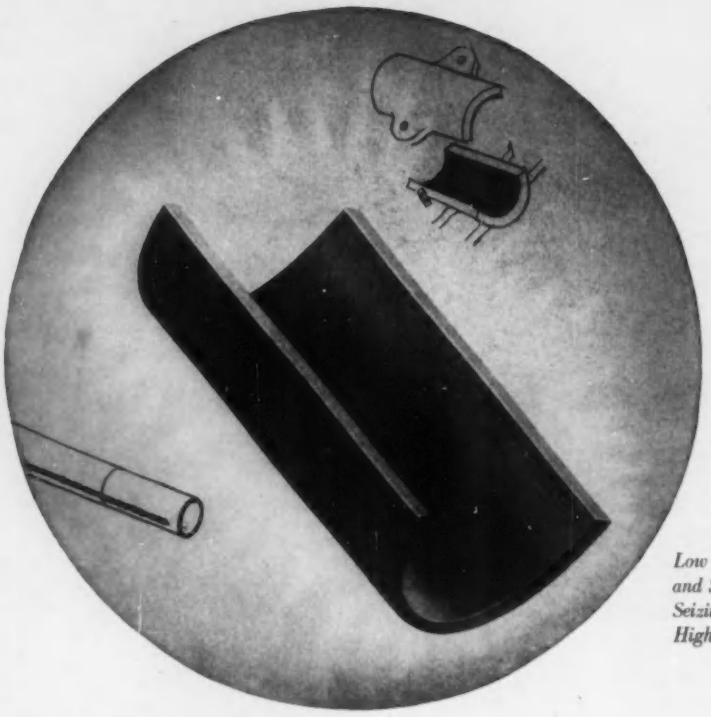
AMERFINE —*high quality fine wire.*
AMERSPRING —*music steel spring wire.*
AMERTEMP —*heavy-duty oil-tempered wire.*
AMERLOY —*alloy heading wire.*
AMERHEAD —*uniform heading wire.*
AMERSTITCH —*extra-tough metal stitching wire.*

UNITED STATES STEEL



Low Friction Bushings and Sleeves Resist Seizing, Abrasion, High Temperatures

HAYNES STELLITE Bushings and Sleeves

Trade-Mark

...for handling Hot-Abrasive Materials

Bearing parts made of HAYNES STELLITE alloy resist seizing and galling. They are hard and abrasion resistant, and will withstand the pitting effects of many corrosives. They take a high polish and are easy to apply. Use them to reclaim worn shafts or bearing blocks, and to lengthen the life of new equipment.

Operate with Little or No Lubrication

Sleeves made of HAYNES STELLITE alloy can be used in areas where efficient lubrication is impossible. They resist seizing even when lubricants are diluted by gasoline, cleaning fluids, and other liquids that wash out an oil film. They operate at peak efficiency even when lubricants decompose under heat, or are destroyed by abrasive particles.

Tough and Abrasion-Resistant

Bearing parts made of HAYNES STELLITE alloy resist the abrasive effects of wet or dry materials such as fly ash, coke, metal powder, shale, and cement dust. They are hard enough to carry heavy loads, and tough enough to stand up under repeated stress.

Heat and Corrosion Resistant

These bushings and sleeves can be submerged in many acids, alkalies, and molten metals. Temperatures as high as 1500 deg. F. have little effect on their hardness, toughness, and dimensional stability.

For more information write for our 8 page booklet on half bushings and sleeves.

"Haynes" and "Haynes Stellite" are registered trade-marks of Union Carbide and Carbon Corporation.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

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DOW CORNING CORPORATION

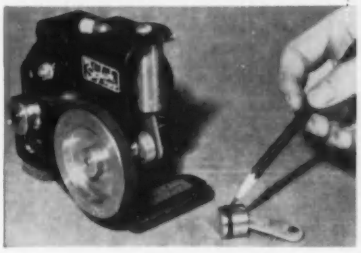
Silicone News

FOR DESIGN ENGINEERS No. 32

Silicone Compound Outlasts Organic Grease as a Lubricant for Rubber

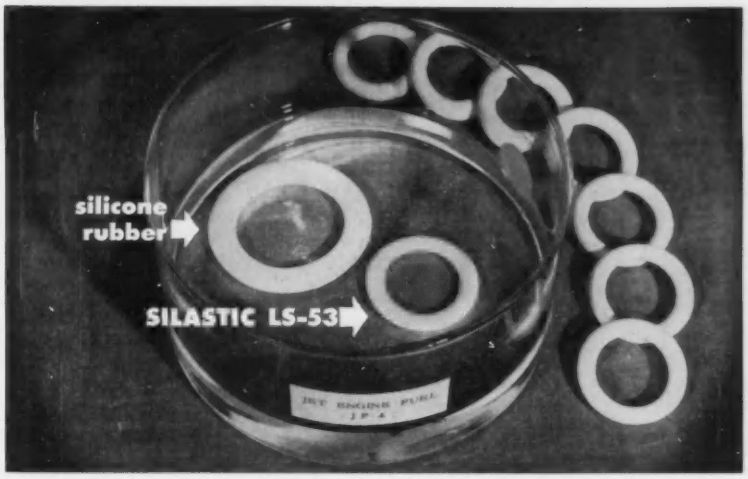
Few, if any, products with moving parts offer absolute dependability and freedom from maintenance. It is significant, however, that many designers are making progress in this direction with Dow Corning Silicones. Take the Skylark Aquarium Pump, produced by W & W Mfg. Co., Cuyahoga Falls, Ohio, for example.

This small pump is designed to continuously aerate water in small aquariums. Originally, organic lubricants were used to keep the Buna N rubber piston ring from drying out and seizing the aluminum piston and brass cylinder. But with even the best organic greases, monthly relubrication was a definite requirement.



Searching for a longer lasting lubricant, W & W finally found the solution in Dow Corning 3 Compound. Chemically inert, 3 Compound greatly prolongs the life of any

(cont'd pg. 2)



NEW FLUOROSILICONE RUBBER RESISTS FUELS, OILS, SOLVENTS

A new kind of heat and cold resistant rubber, fluorosilicone rubber, has been developed by Dow Corning research chemists working in conjunction with the Materials Laboratory of Wright Air Development Center. Identified as Silastic LS-53*, this new rubber has outstanding resistance to swelling in contact with jet fuels, gasoline, high aromatic oils and many solvents.

Silastic LS-53 resembles conventional silicone rubbers in that it has comparable tensile strength, ultimate elongation and compression set, and remains rubbery at temperatures from —80 to 400 F. However, the solvent resistance of this new fluorosilicone rubber is far superior to regular silicone rubbers. Typical properties of Silastic LS-53 are outlined in Table I.

*T.M. REG. U.S. PAT. OFF.

TABLE I

Color	Red
Specific Gravity	1.4
ASTM D676-49T Hardness[1], Shore A Scale	50
ASTM D412-51T Tensile Strength[1], psi	800
ASTM D412-51T Elongation[1], percent	250
ASTM D395-53T, Method B Compression Set[2], percent	30
Water Absorption, 70 hr at 212 F Durometer Change	—2
Volume Change, percent	+3
ASTM D746-54T Brittle Point, degrees Fahrenheit	—90

[1] Molded 5 minutes at 260 F; oven cured 24 hours at 300 F.
[2] 22 hours at 300 F

Illustrating resistance to jet fuels, O-rings made of Silastic LS-53 swelled only 20 percent when immersed for 70 hours in an aromatic test fuel at room temperature.

(cont'd pg. 2)

DOW CORNING SILICONES PUT NEW SALES APPEAL IN APPAREL

The "design engineers" of the textile industry are now employing Dow Corning Silicones, under the trade name "Syl-mer*," to impart water repellency to fabrics; give them long lasting protection against water-borne stains; and to make the fabrics softer, more luxurious feeling, and highly resistant to wrinkling.

Richman Brothers, for example, are currently offering a large selection of Syl-mer finished suits, slacks and top coats at all of their 106 stores. The Syl-mer process is also being used with excellent results on upholstery fabrics, and many leading furniture manufacturers including Kroehler and Simmons, now feature Syl-mer. *No. 319*

FABRIC
SYL-MER
Repels rain and water borne stains, feels better; stays new looking longer with less cleaning and pressing.
Another contribution to carefree living through Dow Corning Silicones

Look for the Syl-mer tag. It's your assurance of Dow Corning quality in silicone finished apparel and upholstery fabrics. *T.M. REG. U.S. PAT. OFF.

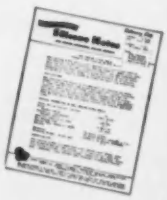
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .



"The Effect of High Temperature on the Properties of Organic and Silicone Rubbers," reprinted from RUBBER AGE, contrasts the effects of heat and heat aging on ten types of rubbers, gives a good indication of their respective serviceability at various elevated temperatures. *No. 323*

Antifoam B, a new silicone defoamer, has greater stability than any other water dilutable silicone foam-killer commercially available. Will not separate, oil out, plate out, settle or precipitate in most applications. Retains uniformity and effectiveness even if frozen or boiled. Ready to use, it eliminates need for diluting or pre-mixing. *No. 324*

Reference Guide to Dow Corning Silicones. A comprehensive, 12-page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 325*

"Effects of Radiation on Organopolysiloxanes," a research paper reprinted from Industrial and Engineering Chemistry, describes the effects of secondary radiation from 4 different sources on organopolysiloxanes. Sources include cyclotron radiation, cobalt — 60 gamma, electron, and X-ray. Results indicate that siloxanes containing large amounts of phenyl substitutions may be good construction materials around high energy radiation units. *No. 326*

Dow Corning Release Agents for Plastics are described in a concise, comprehensive data sheet, that describes the forms available and lists typical uses, including concentrations used for a variety of plastics. *No. 327*

Encapsulating Electrical and Electronic Parts with Silastic is the subject of a data sheet that provides details of handling heat-vulcanizable and room-temperature-vulcanizable silicone rubbers in such applications. *No. 328*

Silicone Insulation Eliminates Power Bottlenecks

When the Ohio Valley Electric Corporation designed its new Clifty Creek and Kyger Creek Plants to supply power for the AEC's new Portsmouth (Ohio) Area Project, it specified a 50 C (122 F) ambient and a 70 C (158 F) rise for its twenty-two 1500 hp fan motors. But OVEC also specified that the motors be silicone (Class H) insulated.

When the two plants were put on the line in January 1955, it became evident that their actual generating capacity exceeded design estimates. Ordinarily nothing could be done to take advantage of the extra capacity because plant auxiliaries, such as these fan motors, are restricted to design ratings.

But because the motors are silicone insulated, they easily withstand a boost in operating temperatures from the specified 120 C up to 160 C. This enables OVEC to raise their output from 1500 to 2060 hp. An OVEC engineer made this typical comment, "Silicone insulation helps us obtain maximum output from every plant." *No. 321*

SILICONE COMPOUND *(continued)*

organic rubber, thereby providing long-term lubrication. A thin coating applied to the ring has kept a positive but smoothly operating seal on a test pump for more than 6 months. W & W estimates a single coating of Dow Corning 3 Compound will last an entire year or 12 times the service life of the best organic grease previously used. *No. 320*

FLUOROSILICONE RUBBER *(continued)*

As shown in Table II, one of the best general purpose silicone rubbers swelled over 200 percent under the same condition.

The properties of the new fluorosilicone rubber suggest increased serviceability and reliability for rubber components exposed to extreme heat or cold, and to solvents. Presently limited to use in essential Air Force applications, Silastic LS-53 should also have a wide range of applications in the commercial aircraft, chemical, petroleum, and automobile industries. *No. 322*

TABLE II
SILASTIC LS-53, OIL AND FUEL RESISTANCE[1]

Test Fluid	Silastic LS-53 Vol. Change, %	Silicone Rubber Vol. Change, %
ASTM No. 3 Oil 70 hrs. at 300 F	+ 5	+ 65
ASTM Ref. Fuel B[2] 24 hrs. at 70 F	+20	+225
Jet Engine Oil[3] 70 hrs. at 350 F	+ 5	+30
Hydraulic Fluid[4] 24 hrs. at 160 F	+11	+163

[1] All samples cured 24 hours at 300 F.
[2] MIL-H-3136, Type III. [3] MIL-L-7808.
[4] MIL-O-5606.

Dow Corning Corporation, Dept. 0611, Midland, Michigan

Please send me: 319 320 321 322 323 324 325 326 327 328

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

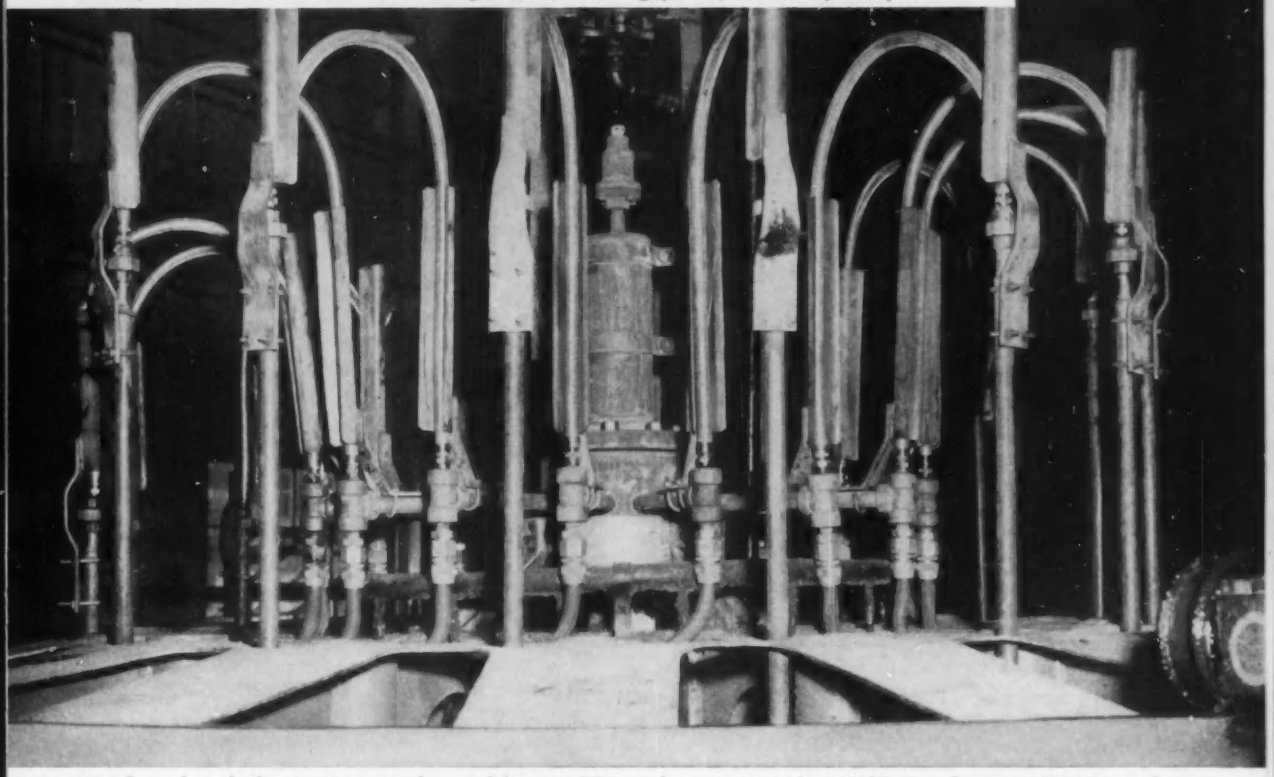
SILICONE NEWS is published for product design and development engineers by

DOW CORNING MIDLAND — *first in silicones* DOW CORNING SILICONES — CORPORATION MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D. C. (SILVER SPRING, MD.)
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

Where you convey steam

and have problems of vibration, misalignment, moving parts, or cramped space.



LIVE STEAM flows through this American stainless steel hose at 230 pounds per square inch at 390°F. Hose flexes over 100 times an hour.

You get absolutely "tight" conveyance—under high or low temperatures and pressure—with American Flexible Metal Hose!

Live steam "on the loose" can be costly . . . and dangerous. That's the problem facing the Diamond Match Company. The job: conveying live steam around a 180° bend . . . in a conveyor which must undergo continuous flexing.

Many lines were tried—and failed. American stainless steel hose was finally suggested, and is now doing the job! This is not unusual. American flexible metal hose has a long record of peak performance in the field.

It absorbs vibration and prevents its transmission to surrounding structures . . . absorbs expansion and contraction in lines due to temperature changes . . . facilitates installation, especially in cramped spaces . . . and solves the problems of misalignment.

Available in wide range of diameters in tough bronze, steel, super nickel, brass, stainless steel and other metals, American flexible metal hose delivers the very highest service hours per dollar. American furnishes flexible metal connectors to your specifications . . . ready for immediate installation.

Consult your nearby American Metal Hose representative for engineering help when planning your next job. No obligation. See American Brass Company or Anaconda in your phone book—or write: American Metal Hose Division, American Brass Company, Waterbury 20, Conn.

56178

WHEREVER CONNECTORS MUST MOVE **AMERICAN**

flexible metal hose and tubing

AN **ANACONDA**® PRODUCT

Contact American to solve problems of . . .

MISALIGNMENT

VIBRATION

CRAMPED SPACES

MOVEMENT

THE SURPRISINGLY VERSATILE

HEIM Unibal

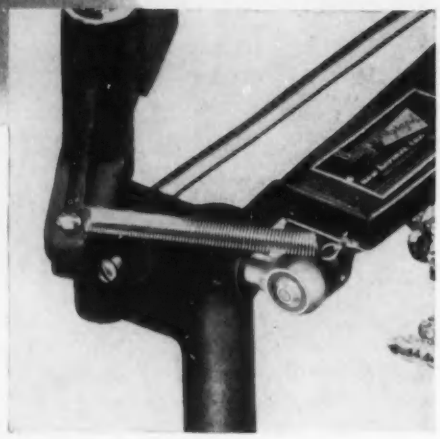
When a Rod End is **Not** a Rod End . . .

The Heim Unibal Rod End was originally designed to act as a self-aligning bearing terminal for push-pull rods. As a spherical bearing rod end, it has universal application and has solved many a linkage problem.

Many manufacturers discovered the versatility of the Heim Rod Ends and how inexpensively they could be applied as self-aligning supports for shafts, as superior pillow blocks, and as take-up bearings.

One example of how perfectly the Heim Unibal Rod End can be used for other than a push-pull linkage, is the New Hermes Engravograph, a machine for engraving watches, jewelry, silverware, and other articles with irregular surfaces.

Here two male rod ends are screwed into the casting to support the engraving arm. The rod ends make possible a smooth, dependable motion which compensates for misalignment and unevenness caused by irregularity of the working surface.



The male rod end is attached by drilling a hole in the work, tapping for proper thread fit, and screwing in the rod end.

The female rod end may be attached by drilling a hole in the work and drawing the rod end tight with a machine screw.

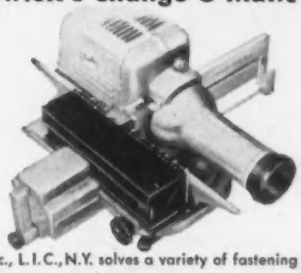
SEND FOR THE COMPLETE HEIM CATALOG NO. 100

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

HAS MANY USES OTHER THAN STRICTLY ROD END APPLICATIONS

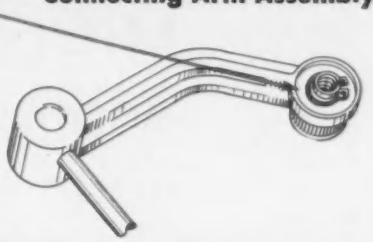
Waldes Truarc Rings Permit Better and More Economical Design—Fewer Parts, Faster Assembly, Minimal Rejects!

Viewlex's Change-O-Matic



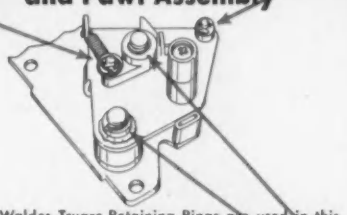
Viewtex, Inc., L.I.C., N.Y. solves a variety of fastening problems in their new model Change-O-Matic automatic slide changer. Assembly time is speeded, parts eliminated, rejects lowered, and compact, economical product design achieved.

Connecting Arm Assembly



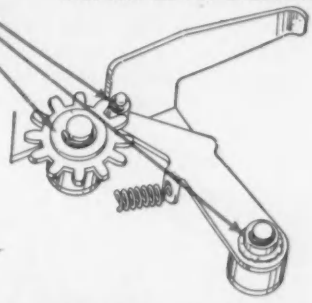
Use of one Waldes Truarc Ring (Series 5100) eliminates time-consuming riveting over the flange, retains and holds the connecting knob captive. A compact, neat design is made possible, rejects caused by poor riveting eliminated.

Actuating Plate and Pawl Assembly



Three types of Waldes Truarc Retaining Rings are used in this assembly. One circular self-locking ring (Series 5106) retains pawl return spring. One external E-ring (Series 5133) retains roller used to prevent gear motion during transport cycle. One crescent ring (Series 5103) retains pawl which indexes gear. Second crescent ring retains sub-assembly. Truarc Rings speed assembly, cut rejects, eliminate parts.

Detent Lever Assembly



Truarc E-ring (Series 5133) eliminates use of tapped hole and shoulder screw, retains roller which prevents over-travel of gear. Assembly is rapid.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

Send for new catalog supplement

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

*Name*_____
*Title*_____
*Company*_____
*Business Address*_____
*City*_____ *Zone*____ *State*_____

PN118

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

MICRO precision switches

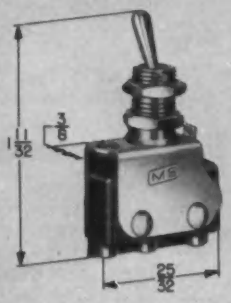
....THEIR USE IS A PRINCIPLE OF GOOD DESIGN

make MICRO SWITCH engineering service your short cut to NEW DESIGN IDEAS

MICRO SWITCH Engineering Service is devoted to assisting industrial designers in the solution of complex switching problems.

This service—as close as your telephone—places at your disposal a knowledge of switch applications obtained through years of research and field experience. We are experts on just one thing—precision switching problems.

We may have already solved a problem similar to yours—for somebody else. Should your problem turn out to be entirely new, MICRO SWITCH can—and will—develop the switch you need.



RELIABLE TOGGLE SWITCH where inches and ounces count

Two of these MICRO SWITCH Type "AT" subminiature toggle switches serve as components for a small, lightweight portable geiger counter.

The extreme reliability and long life of the extremely small MICRO SWITCH units were important factors in their choice by the design engineers. This switch weighs but .02 lb. It has single-pole, double-throw contact arrangement. Rating of basic switch is 5 amperes 125 or 250 volts a.c.

(Send for Catalog 73B—"Toggle Switches" and 75A—"Subminiature Switches")

LIMIT SWITCHES operate 57,000 times a day—day-in, day-out

MICRO SWITCH "ML" Type limit switches—17 of them—are used in an automatic grinding machine to control the steps in grinding small parts. Features which governed their selection by the design engineers were:

1 **Long Life:** some switches operate every 1½ seconds, three shifts a day—over 57,000 operations a day.

2 **Precision:** switches repeat exact operating point through millions of precise operations.

3 **Protection:** switches are well housed and protected against effects of oil splash, dirt and dust.

4 **Versatility:** three different types of actuating heads are used. Switches are adjustable to meet varied types of actuation and for mounting in cramped quarters.

(Send for Catalog 83—"Industrial Enclosed Switches")

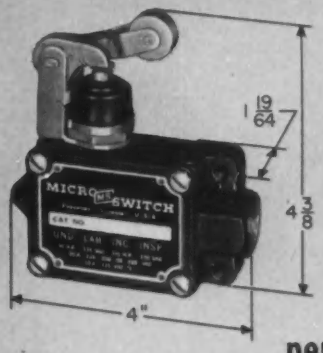
...have uses unlimited

MERCURY SWITCH accurate to ⅛ inch in 12 feet on grader

(Send for Catalog 90-A—
"HONEYWELL Mercury Switches")

Mercury switches are not usually associated with such applications as heavy road grading machinery. However, four of these protected HONEYWELL Mercury Switches have proved successful as grader blade controls.

Tilt action of the switches actuates a series of power relays and valves to control the grader blade. The switches are so sensitive that they are able to control the level of the blade within ⅛ of an inch in an overall movement of 12 feet. The switches—embedded in epoxy within a metal case—are extremely resistant to shock and exposure to the elements.



MAXIMUM ACCURACY plus long-life performance

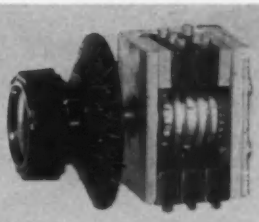
Switches used in woodworking production equipment—cut-off saws, rip saws, gang saws and jointers—must take a lot of punishment and retain maximum accuracy for a long life.

These enclosed switches, with roller arm actuator and sealed plunger, were chosen by designers as controls on an automatic air-operated cut-off saw. One switch controls the reversing of the solenoid for length of stroke. The other is a return control.

Both switches must operate with maximum accuracy and give long-life performance. At an average of 1,250 strokes per hour, the switches are activated 10,000 times in the average 8-hour work day.

(Send for Catalog 83A—
"Industrial Enclosed Switches")

FIVE tiny switches permit 32 on-off situations



Five MICRO SWITCH subminiature switches were selected by design engineers in this rotary selector switch to provide the switching function for each of the pulse positions in a five-pulse binary code switch. Each switch is of single-pole, double-throw design, thus providing 32 on-off current combinations for data processing equipment.

The binary switch is a single control, positive locking, electro-mechanical device for converting rotary operation into a binary sequence.

According to the designers, the MICRO SWITCH subminiature switches were chosen because of:

1. Small size and light weight (¾ x ½ x ¼ inch)—(265 per pound).
2. Ease of operation.
3. Reliability.
4. Extremely low contact resistance (through use of fine silver).
5. Positive make and break action.
6. Resistance to shock and vibration.
7. Low capacitance between open contacts and from terminals to ground.

There is no limitation in the design as to the number of switches that can be used.

(Send for Catalog 75A—"Subminiature Switches")

MICRO SWITCH
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Typical Mechanical Properties of Ni-Vee Bronzes

TYPE	A (lead free)			B (1% lead		C (5% lead)		D (10% lead)		E (20% lead)	
	As Cast	Tempered	Heat-Treated	As Cast	Tempered	As Cast	Tempered	As Cast	Tempered	As Cast	Tempered
Tensile Strength (thousand psi)....	50	65	85	45	60	40	50	35	40	25	30
Yield Strength (thousand psi).....	22	40	55	20	30	20	30	20	25	18	22
Elongation, % in 2"....	40	10	10	30	8	15	5	10	2	5	2
Brinell Hardness....	85	130	180	80	120	80	130	80	110	70	80

Specifying is simple and systematic with 5 versatile Ni-Vee Bronzes

Now . . . designers and engineers can readily select a suitable bronze for any specific need . . . from only five Ni-Vee* bronzes.

"As Cast," these five Ni-Vee bronzes provide mechanical properties that surpass those of comparable G bronze, red brasses and leaded bearing bronzes. What's more, their superior properties can be still further elevated by simple heat-treatments.

Basically, each Ni-Vee bronze contains 5% nickel and 5% tin, from 0 up to 20% of lead. Tensile strength ranges from 25 to 85 thousand psi, and hardness from 70 to 180 Brinell.

Advantages

Just five of these Ni-Vee bronzes make it possible to standardize metal inventories, melting practices and shop operation . . . as well as specification . . . to meet many industrial uses for copper-base castings.

Each Ni-Vee bronze contains an optimum nickel content to raise levels of strength, hardness and toughness. In addition, this nickel content provides a high degree of corrosion resistance in the Ni-Vee bronzes. Negligible zinc content makes it free from dezincification. This spells resistance to stress-corrosion attack.

A versatile family

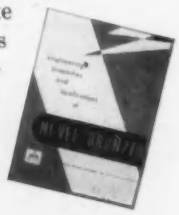
Copper-base alloys are ordinarily used for the three types of castings listed below. For each of these applications a Ni-Vee bronze provides particular advantages:

(1) **Constructional** castings – high strength
(2) **Pressure** castings – fine grain
(3) **Bearing** castings – resistance to wear and seizure

The simple family of five Ni-Vee bronzes actually replaces the confusing variety of miscellaneous bronzes. As a result, engineers and designers can now specify simply and systematically . . . specify Ni-Vee bronzes wherever possible. Parts cast in Ni-Vee bronze already serve *electrical, power, steel, petroleum, chemical, automotive, aircraft, railroad and other industries.*

Engineering data for you

Learn how the Ni-Vee bronzes can simplify your specification work, improve product performance. Send for a copy of *"Engineering Properties and Applications of Ni-Vee Bronzes."* It contains useful information like that given in the table above: tables of composition, charts on deformation, friction, fatigue, elevated temperature service, electrical resistivity, wear and other engineering data. *Write for it now.*



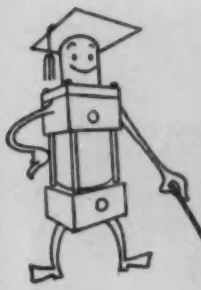
*Registered trademark

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

Miller

FLUID PRESSURE BOOSTERS

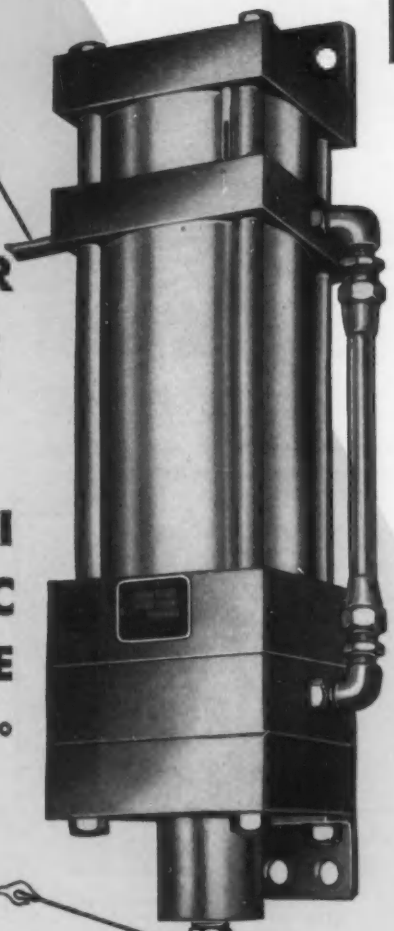


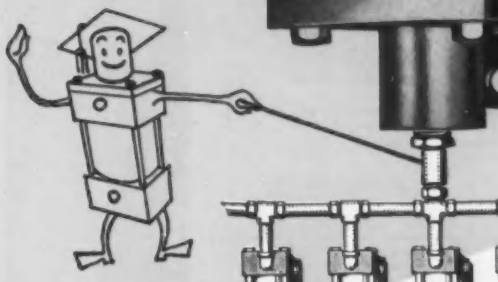
BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

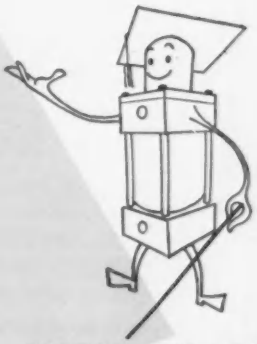
Output Range: 200 to 10,000 psi Fluid





- Save space, weight and investment cost by replacing pump installations in many applications
- Less costly to install, operate and maintain
- **Hold pressure indefinitely** without the motion and heat generation of ordinary pump circuits
- Provide — at point of cylinder thrust — more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery, Miller offers 5" bore 25 to 1 ratio boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.



ESPECIALLY RECOMMENDED FOR

- **WELDING**
- **PUNCHING**
- **SHEARING**
- **CLAMPING**
- **RIVETING**
- **CRIMPING**
- **PRESSING**

and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST

Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

2002-04 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

ANNOUNCING THE

TO HELP YOU COMPARE a U. S. PowerGrip XX Heavy Duty "Timing" Belt drive with the four other common forms of power transmission of equal capacity, a power transmission engineer offers his recommendations based on published application and load ratings, for the following:

A 300-HP drive (at 1160 rpm.) including application factors. 3.00: 1 speed reduction. Approximately 50" center distance.

Here, complying with minimum pulley sizes and other practices commonly observed, are his recommendations (with approximate comparative cross sections of space occupied by each drive):

"TIMING" BELT DRIVE

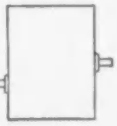
Belt: XXH "Timing" Belt 10" wide by 160" P. L.
Motor Pulley: 9.549" P. D. (24-groove) 1¼"-pitch
Driven pulley: 28.648" P. D. (72-groove) 1¼"-pitch
Belt speed: 2900 feet per minute

V-BELT DRIVE

Belts: 10 Super Service "D"-Section V-Belts (DP-225)
Motor pulley: 18.0" P. D. x 10 D-groove, 14¾" wide
Driven pulley: 54.0" P. D. x 10-groove, 14¾" wide
Belt speed: 5380 feet per minute

GEAR DRIVE

Herringbone gear speed reducer with 3:1 ratio. (A typical reducer of required capacity weighs 1440 lb., measures 33" long, 26⅛" high and 19" wide.)



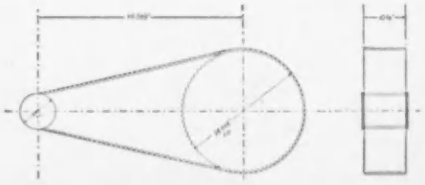
ROLLER CHAIN DRIVE

Chain: #80-8 (8 strands) 1"-pitch x 152 pitches
Motor sprocket: 7.979" P. D. (25 teeth)
Driven sprocket: 23.880" P. D. (75 teeth)
Chain speed: 2380 feet per minute
(Requires Type #3 lubrication with oil-tight case for sump pump)

FLAT BELT DRIVE

Belt: 21" wide x 8-ply x 18' 4" long
Motor pulley: 18" O. D. x 23" wide
Driven pulley: 54" O. D. x 23" wide
Belt speed: 5380 feet per minute

Schematic of "Timing" Belt drive used for comparison above



Rubber cut away to show steel cables

THE "TIMING"® BELT DRIVE FOR HEAVY-DUTY MACHINERY

THIS LIFE-SIZE illustration only begins to suggest the brute strength built into this double extra-heavy-duty tooth-grip belt with steel-cable tension member *designed for drives up to 1000 hp.* Appearance doesn't tell the whole story, because, rating for rating, U. S. PowerGrip "Timing" Belt drives are lighter in weight and occupy less space* than any other form of mechanical power transmission.

Approximately 2½ times larger—and 2½ times stronger—than the standard "Heavy Duty" series, the new XX Heavy Duty drives bring to high-torque power transmission a never-before-obtainable combination of features:

- **Highest-efficiency positive transmission of power.**
- **Complete elimination of drive lubrication (including the problems and accessories involved).**
- **Precise angular synchronization ("Timing") between two or more shafts.**
- **Quiet operation.**
- **Practical elimination of power loss due to slippage, friction and high initial tension.**
- **Compactness and high strength-to-weight ratio.**
- **Belt speeds as high as 7500 fpm.**
- **Low initial cost; no maintenance; long life.**

A complete line of U. S. PowerGrip "Timing" Belts—plus expert engineering assistance—is available at any of the 28 "U.S." District Sales Offices, at selected "U.S." power transmission distributors, or by writing U. S. Rubber, Mechanical Goods Div., Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

*Including accessories required by some other drives.

US RUBBER

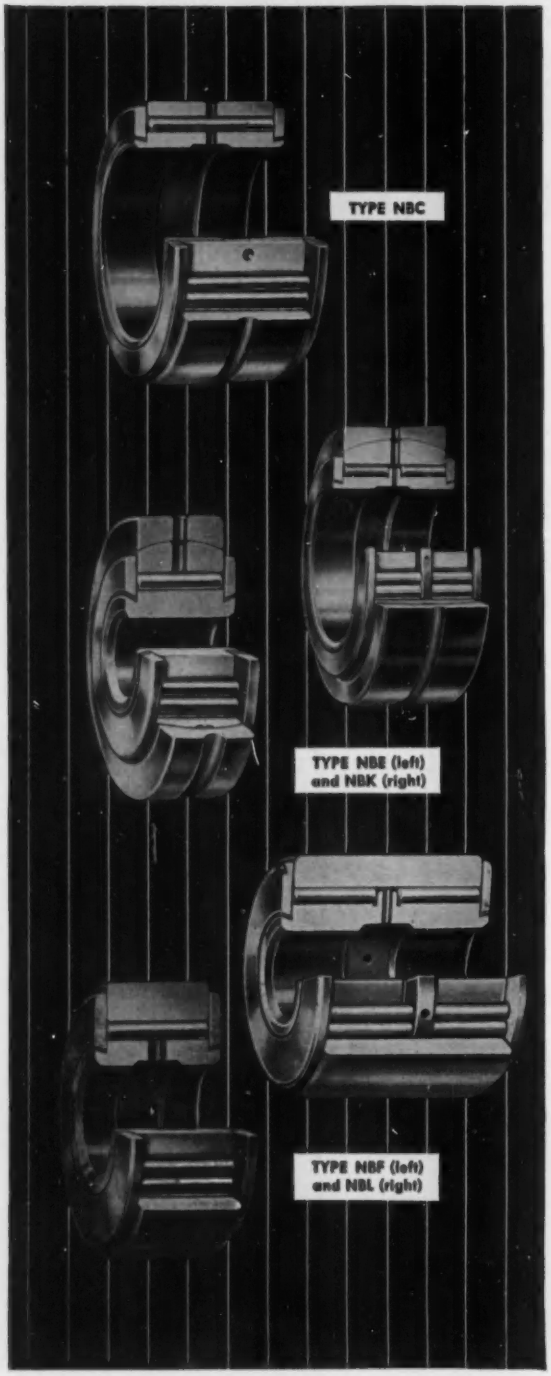
Mechanical Goods Division

United States Rubber

TORRINGTON

NB SERIES NEEDLE BEARINGS

For Oscillating Motion or Heavy Rolling Loads



Torrington NB Series Needle Bearings employ the same needle roller principle as the famous DC Type Bearing.

They are available in the five types illustrated, all being of nonseparable construction and designed for periodic relubrication. Outer and inner races are of high carbon, chrome steel, hardened and precision ground.

Like the DC Type, the compact design of NB Series Needle Bearings permits saving in size and weight of surrounding parts.

Torrington NB Series Needle Bearings have been used extensively in the aircraft industry and for ordnance work where their extremely high static capacity and anti-friction characteristics enable them to withstand heavy impact loads.

Designs can be modified to meet industrial applications involving rotating motion.

Type NBC—oscillating motion only. Designed specifically for applications in which the OD is supported by a housing and the washers are backed up by clamping surfaces.

Types NBE and NBK—oscillating motion only. Self-aligning. Designed for applications where it is difficult to obtain alignment during assembly or where deflections make a self-aligning bearing desirable.

Types NBF and NBL—heavy rolling loads. Designed for use as rollers under heavy loads at slow speeds.

See our new Needle Bearing Catalog in the 1955 Sweet's Product Design File—or write direct for Catalog No. 55.

THE TORRINGTON COMPANY

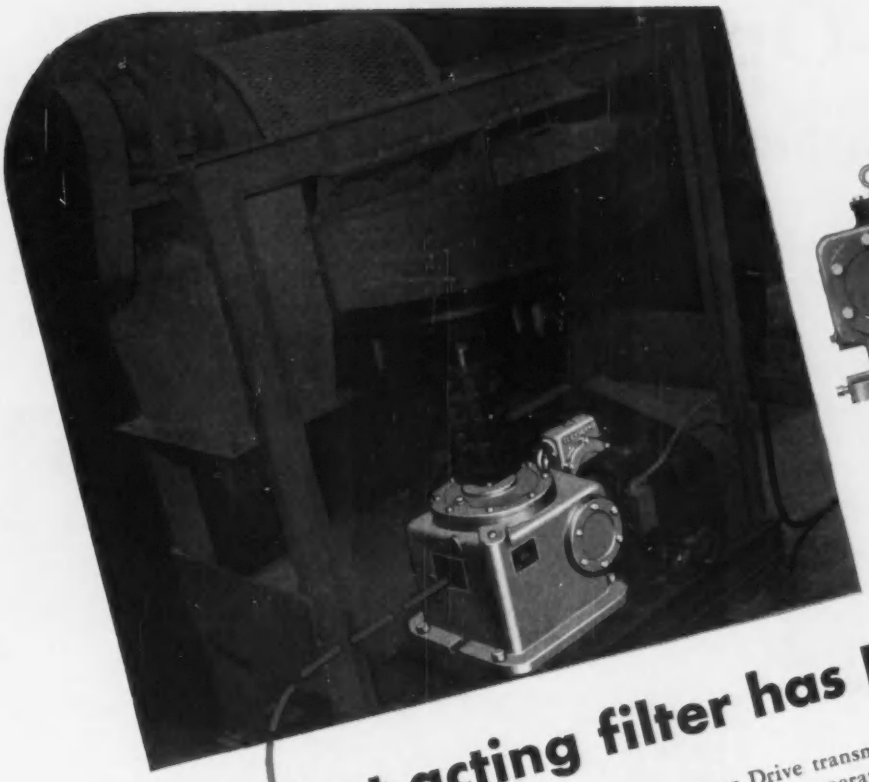
Torrington, Conn. South Bend 21, Ind.

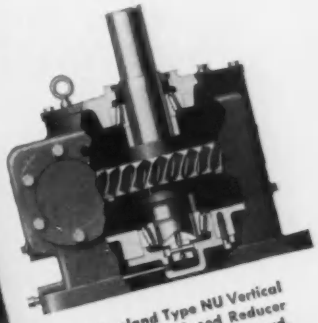
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1866–1956

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller
Cylindrical Roller • Ball • Needle Rollers





Cleveland Type NU Vertical Worm Gear Speed Reducer with drive shaft upward. Cutaway shows heavy gear shaft, rugged shaft bearing mounting and extra sturdy housing construction.

Versatile, fast acting filter has NU drive

CLEVELAND Type NU Worm Gear Drive transmits smooth, uniform speed to permit efficient operation for this Filtration Engineers' Horizontal Rotary Vacuum Filter. For coarse crystalline materials, fibrous pulps and other free-settling substances, it offers high capacity, fast dewatering and excellent cake washing.

It was important that this filter be compact. Right angle construction of the Cleveland Worm Gear saves space. Efficient performance is inherent. There's smooth, uninterrupted torque flow and quiet running. Case hardened steel worm and nickel-bronze gear actually improve with use—will be even more efficient years from now.

Get the complete Cleveland story before you install your next speed reducer; see how much Clevelands can do for you. Write for Catalog 400. The Cleveland Worm and Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

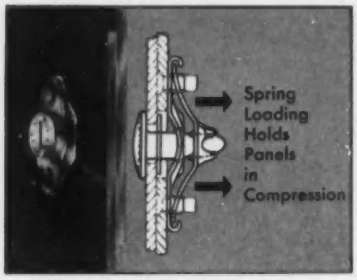
CLEVELAND
Worm Gear
Drives

Quick-Opening Fasteners

Selecting Small Fastenings for Metal Closures

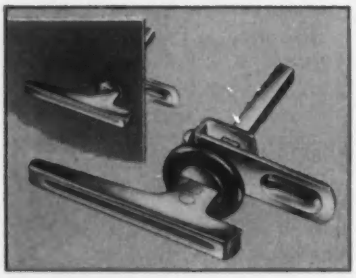
*"Use captive fasteners wherever feasible . . . Avoid the use of loose washers and loose nuts . . . Fasteners on equipment covers should be operable either with no tools or with standard hand tools"**

(*John D. Folley, Jr. & James W. Altman, Research Scientists, American Institute for Research*)



Quarter-Turn Fastener

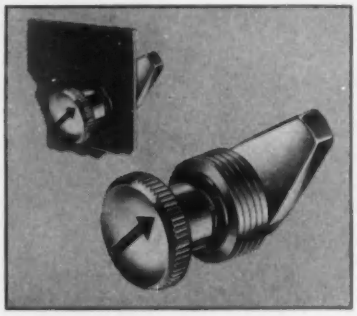
Lion Fasteners open and close with a ¼ turn, hold sheets tightly under the compression of a rugged spring. Quickly operated and fully retained in the outer panel, they are approved under U. S. Government military specifications. Stud and receptacle float for easy alignment and simplified hole preparation. Flush, oval, wing, knurled, ring, and key head styles available. Sizes—No. 2, No. 5, and High Strength for extra heavy duty.



Cabinet Latch

Just drill a hole, push the fastener stem through, and slide the special push-on clip into place. No welds, screws, bolts or rivets: the fastener is permanently installed in seconds!

Adjustable to any grip length or panel thickness, the pawl is fixed in place by a single set screw. The fastener's brightly finished knob is set off by a plated washer. Also furnished with screwdriver operated flush head.

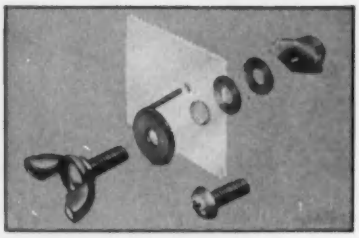


Spring Tension Latch

For fastening slide-out drawers and hinged panels the Southco Arrowhead Latch is recommended. It locks or opens with a quarter turn yet occupies less than ½" inside space.

Doors are held under spring tension—a push against the arrowhead knob relaxes this tension, allows operation with fingertip ease. Drill a single hole for installation—no fastening to the door is necessary. No striker plate is needed.

Pawl stop is eliminated—arrowhead shows at a glance exact position of pawl.



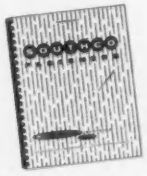
Adjustable Panel Latch

Small doors and panels can be fastened with greatest speed and lowest cost with the Southco Adjustable Latch.

The entire fastener is quickly installed through two holes punched in the door; no bolts or rivets are needed.

It operates with a quarter turn, requires no striker plate. An extra twist after the nylon pawl is engaged pulls up the door to form a seal and eliminate vibration.

Available with wing, knurled, or Phillips head.



Free Fastener Handbook

Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other special fasteners. Fifty-two pages, in two colors.

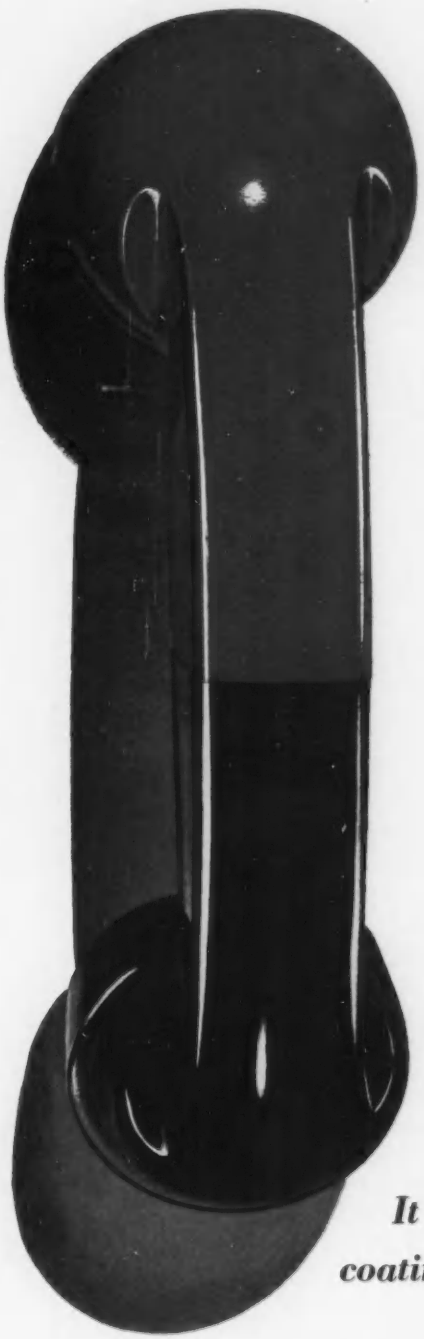
Write on your letterhead to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

©1956

* *Quotation from "Designing Electronic Equipment for Maintainability"; Machine Design, July 12, 1956.*



Here's a NEW way to

Have color...and keep costs down

You can do just that, with phenolic moldings economically and permanently colored (without the use of prime or multiple coats) by a new coating based on BAKELITE Brand Epoxy Resins.

Phenolics, of course, are recognized for their low cost, easy moldability, excellent dimensional stability and electrical insulating properties, resistance to heat, water and chemicals. But, until now, they had to be passed by when bright color was a requirement. Therefore, color meant higher costs with other materials.

Today, with the development of this new coating, manufacturers can have color in a single coat and still retain the production economies and quality advantages of phenolic moldings.

BAKELITE Epoxy Resins are well known for their adhesive properties. The new enamel not only adheres firmly to the glossiest phenolic surface, but equally well on steel, tin, brass, copper, aluminum, wood, and many other plastics. It has excellent heat, corrosion, chemical and abrasional resistance. A wide range of colors is available, with finishes from dead flat to high gloss. Curing is by air drying, force drying, or baking. Air-dry pieces can be handled in about two hours . . . and the possibility of curing with low or no heat opens up the field of precision parts to color. A further advantage in production is that color is switched at the spray booth, not at the molding machine. Changeover time is eliminated. Inventory of colored raw materials is cut.

Investigate these new coatings. They can give you new ideas on how to design for color . . . as well as economy. Write Dept. VJ-145.

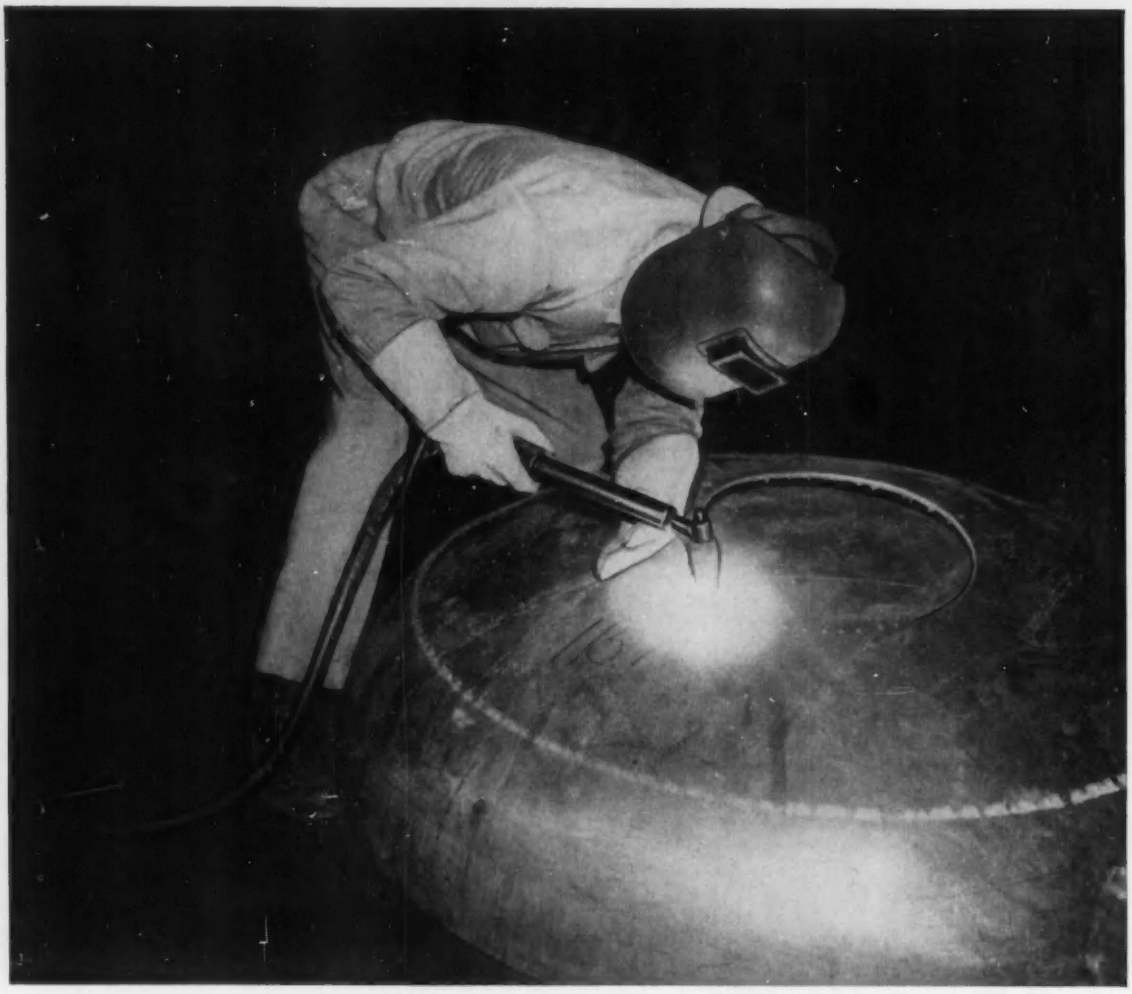
It pays to specify coatings based on...

BAKELITE
BRAND
EPOXY RESINS

Rexton Finishes, Inc., Irvington, N. J., developed the coatings described.

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.



from one hour to one minute...

HELIARC Cutting Whizzes Through Aluminum

One of the first aluminum fabricators to use LINDE's new HELIARC cutting process reveals savings of more than 95 per cent over conventional chipping methods—jobs normally requiring 1 and 5 hours to complete are whisked through in only 1 and 4½ minutes respectively. Graver Tank and Manufacturing Company reports beveling, grooving, shaping, and cutting are all performed on ⅝-in. thick, 52S aluminum plate at substantial time, space, and cost savings.

Incredible, but true: HELIARC cutting can attain speeds as high as 600 inches per minute, and cut aluminum in thicknesses up to 1½ inches. No special skill is required. A certified welder can do excellent cutting jobs after less than one hour of instruction.

Get the full story on revolutionary new HELIARC cutting. Call your LINDE representative, or write for free illustrated literature, Form 50,095.

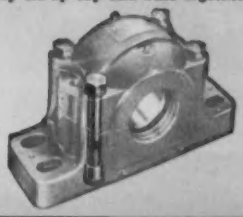
Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

"Heliarc" and "Linde" are registered trade-marks of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

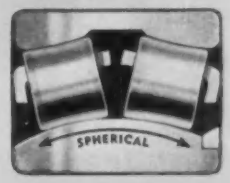
MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

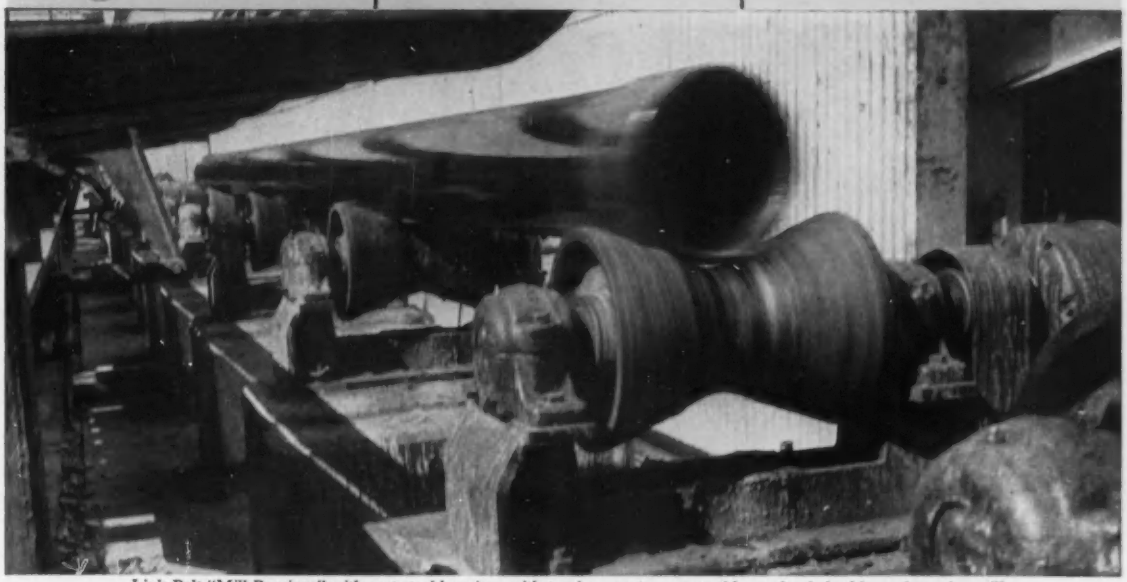
SUPER-RUGGED CAST STEEL HOUSING. Proper positioning of cap on base is assured by large-size dowels. Four heat-treated thru-bolts and serrated steel nuts firmly clamp cap and base together.



CHOICE OF SEALS. Spiral labyrinth steel seals, left, are for oil or grease lubrication and heat conditions. Combination felt and synthetic rubber contact-type seals, right, for grease lubrication.

SELF-ALIGNING ROLLER BEARING is self-contained and adjusted at the factory—needs no shims or alignment rings at installation. Design assures free rolling under even the toughest conditions.





Link-Belt "Mill Bearings" with cast steel housings withstand severe impacts and heavy loads in this modern pipe mill.

"Mill Bearings" with cast steel housings

designed by Link-Belt to take industry's heaviest loads and hardest impacts

"Mill Bearings" are now available for shafts up to 11 in.

● To stand up to the sudden shocks and impact loads met in steel mills, mines, foundries, oil field applications and on heavy equipment, Link-Belt has designed the extra tough "Mill Bearing." It's the precision Link-Belt self-aligning roller bearing mounted and protected in a durable cast steel housing.

Thoroughly-proved Link-Belt "Mill Bearings" maintain full load capacity even with shaft deflections and misalignment often existing in extremely heavy service. And their simple, efficient design assures long life and free rolling.

Link-Belt makes industry's most complete line of ball and roller bearing blocks. So whatever you need, you'll find the answer in this quality line. Ask any of the 40 Link-Belt offices for Data Book 2550 and Book 2565A on "Mill Bearings."

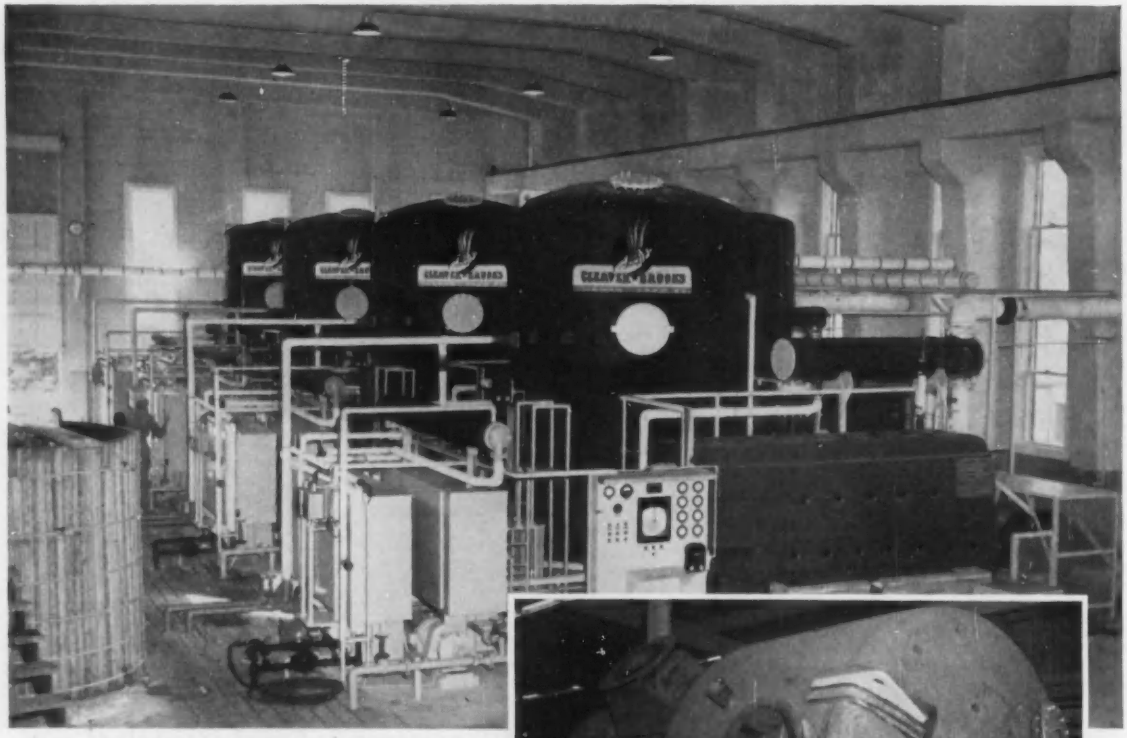
13,902-A

LINK-BELT

Ball and Roller Bearings

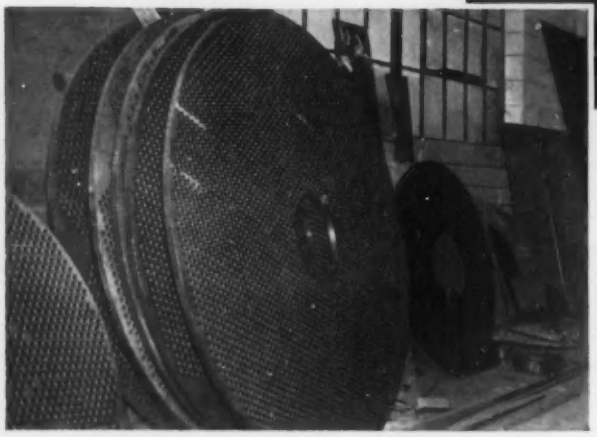
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

World's



BATTERY OF CLEAVER-BROOKS EVAPORATORS IN ACTION—Revere Silicon Bronze was chosen for these evaporators and their component parts because of its high corrosion resistance and non-contamination properties, great strength and weldability. All of the components, as well as the 4 evaporator shells, are made of Revere Silicon Bronze Alloy No. 420.

ONE OF THE 4 EVAPORATOR SHELLS made of Revere Silicon Bronze, fabricated and installed by CLEAVER-BROOKS MFG. CORP., Waukesha, Wisconsin.



EIGHT TUBE SHEETS LIKE THESE were used in the Bermuda installation . . . 2 per evaporator. Each tube sheet, made of Revere Silicon Bronze, is 86" in diameter, 1¼" thick and weighed approximately 1,360 lbs. after drilling.

Largest

VAPOR-COMPRESSION SEA WATER DISTILLATION PLANT

Made and installed by CLEAVER-BROOKS

. . . Vital distillation units fabricated from REVERE SILICON BRONZE

This plant installed at the Kindley Air Force Base in Bermuda has a total daily capacity of 200,000 gallons and eliminates the dependence of the Base on rainfall or shipment of water by tankers.

Distilled water is produced in the ratio of 300 lbs. to each pound of Diesel fuel. Total costs are estimated at $1.25 per thousand gallons of distilled water. Nearly every component part made by Cleaver-Brooks is about twice the size of its largest previous counterpart. For example, the evaporators are 16½ feet high. Each, with its component parts, weighs approximately 40,000 lbs., the empty Revere Silicon Bronze shell alone accounting for 28,000 lbs.

There is an interesting story behind the development and manufacture of this equipment. The four huge pressure vessels had to be fabricated of Revere Silicon Bronze Alloy No. 420. Knowing Revere's wide experience in welding copper-base alloys, Cleaver-Brooks called in a Technical Advisor, and gave him a complete set of blueprints of the vessels, with a request for suggestions regarding joint design and welding techniques. He in turn consulted the Welding Section of the Revere Research Department. Their recommendations were adopted, and the customer reported that the original estimate of welding time had been cut considerably, reducing production costs correspondingly.

The Revere Technical Advisory Service is glad to collaborate on problems involving the specification and fabrication of copper and copper-base alloys, and aluminum alloys. See the nearest Revere Sales Office.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

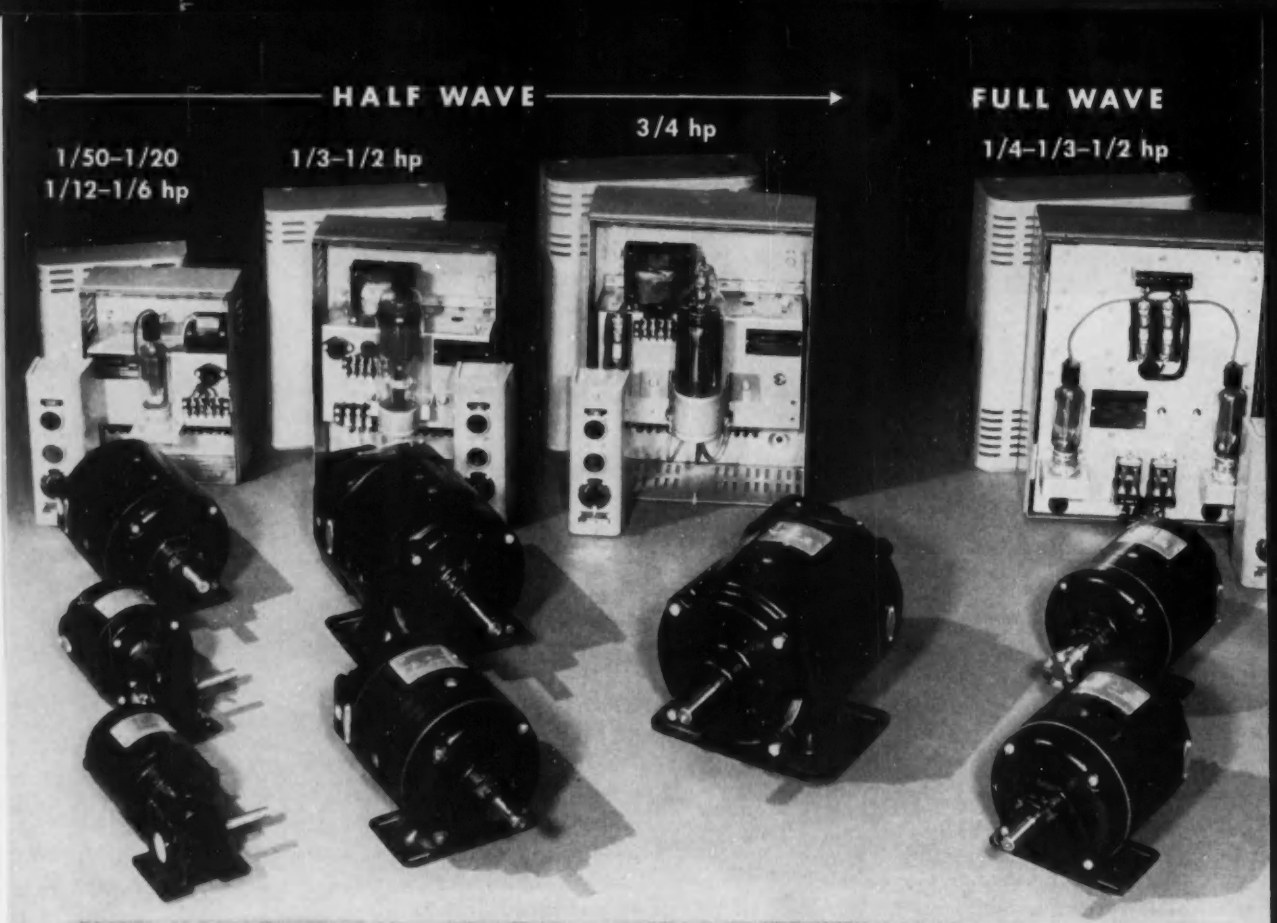
230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

COPPER * BRASS * 1801 * REVERE * ALUMINUM

THE STEAM SEPARATORS are identified by their conical tops and directional vanes. They are of the cyclone type, which is a patented feature of CLEAVER-BROOKS evaporators, and remove entrained water from the steam, thus preventing contamination of the fresh water coming from this unit. The result is an extremely high purity of the fresh water product.

The rectangular objects at rear of photograph are the "Downcomers" which bring water down from the top of the steam separator. The tubes in left foreground are "Hotwells," which receive the distilled water discharge from the evaporator shell.



A DRIVE TAILORED TO EVERY JOB is the achievement of General Electric engineers who designed the new fhp Thymotrol drive line. Here are examples of this versatility:

Three panel sizes now cover the fhp range, making smaller ratings more compact, more economical than ever before.

Full range of ratings

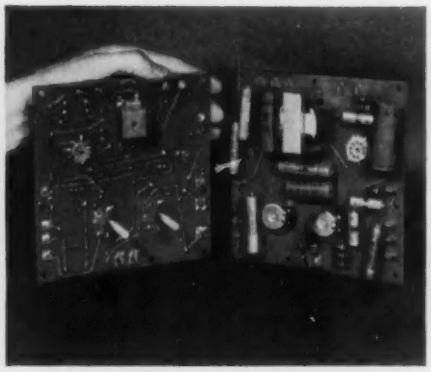
- Horsepower: 1/50 to ¾†
- Power supply: 220 v a-c, 50/60 cycles
- Speed range: 20 to 1
- Speed reg. (NL to FL): half-wave — 3%, full-wave—5% (adjustable to flat at any specific speed)

†Plus a full line of integral-hp drives.

Building-block design—you get the exact performance you want by selecting any combination of these optional features:

- Reversing operation
- Jogging (pre-set or run)
- Dynamic braking
- Tachometer follower
- Overload relay protection
- Tube warm-up protection

ONE-TUBE DESIGN of G-E half-wave Thymotrol drives minimizes tube maintenance. This type drive is suitable for most adjustable-speed jobs.



PRINTED CIRCUITRY, DIP SOLDERING are effective techniques which permit new lower General Electric prices. Exhaustive tests prove the sturdiness of this construction for industrial use.

PLUG-IN PANEL BOARD can be quickly removed for maintenance or replacement to minimize downtime—a must on such jobs as production conveyors.

NEW full line of fractional-horsepower G-E Thymotrol* adjustable-speed drives—more compact, more rugged, more reliable, easier and more economical to maintain, yet priced up to 18% below previous models

General Electric announces a completely re-designed line of fractional-hp Thymotrol adjustable-speed drives—*designed to save you up to 18% over prices of previous models.* These versatile new drives are applicable to conveyors, machine tools, in fact, to almost every small machine whose performance can be improved by adjustable speed.

SELECT JUST THE DRIVE YOU NEED —AND SAVE MONEY!

Biggest cost-saving for you with new G-E Thymotrol drives is that you buy only as much drive as you need. For some applications, you'll want only the basic half-wave drive: motor, simple one-tube control, and control station. For more complex jobs, you can select any combination of seven different optional accessories to provide desired performance. To further match drive to job, these popular half-wave drives come in three panel sizes.

For rapid acceleration of high-inertia loads, for extra-smooth performance, or for flat speed-regulation adjustment, you'll want the new full-wave Thymotrol drive, with still other optional features.

NEW DESIGN IS SIMPLE, RELIABLE

In designing new G-E Thymotrol drives for mass production, G-E engineers have also included many new features for longer life, lower operating costs, increased reliability:

Plug-in panel boards on half-wave units can be quickly removed without disturbing customer wiring for fast inspection, repair, or replacement, minimizing downtime.

Printed circuitry and dip soldering result in more compact units which simplify your design problems. Shock and vibration tests show this construction really stands up in industrial use. Parts replacement is simple using soldering iron and pliers.

20:1 speed range is now standard on all ratings. And operator can turn machine to full "off" with speed-control knob.

High tube reliability—all tubes on G-E Thymotrol drives are fully guaranteed for one year, usually last far longer.

SIMPLE PACKAGED DRIVES OR ENGINEERED MULTI-MOTOR SYSTEMS

Whatever your adjustable-speed needs, from packaged single-motor drives to specially engineered multi-motor systems, you'll find the answer —*at new low prices*—at General Electric. See your G-E Apparatus Sales representative today. Or write for Bulletin GEA-6519 to Sect. 791-3, General Electric Co., Schenectady 5, N. Y.

*Trade-mark of General Electric Co.

Progress Is Our Most Important Product

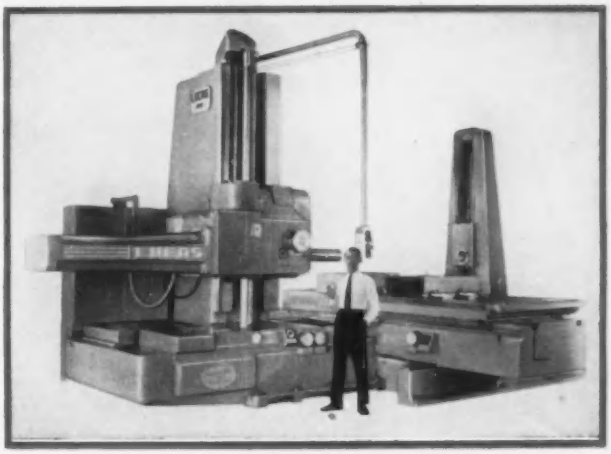
GENERAL ELECTRIC

New XXH 1¼"-PITCH

Upper pulley of spindle drive has 12¾"-pitch diameter. Idler takes up belt slack required for easy installation on fixed-center pulleys.

Gilmer "TIMING" BELT DRIVE

gives boring machine a compact, vibrationless, cushioned spindle drive



HERE'S HOW a leading manufacturer* of heavy machine tools has made excellent use of the new Gilmer "Double Extra Heavy Duty" 1¼"-pitch "Timing" Belt drive. The close-up photo (with cover plate removed) shows the 3"-wide XXH drive which transmits the power of a 30 hp (1800 rpm) motor to the 6" spindle of a Lucas Model 684 or 6120 Horizontal Boring Machine. This drive is used for spindle speeds between 262 and 850 rpm.

Quoting from Lucas' own literature, this non-slip, steel-cable-reinforced, toothed belt "provides the smooth, positive, constant-speed drive required for high-speed boring, drilling or carbide milling. It is free from the vibrations which are normally imparted to the cutter by conventional high-speed gear drives."

Gilmer "Timing" Belt drives, with their constant angular velocity, have been standard equipment for some time on all Lucas Precision Horizontal Boring Machines... and on recent models of automatic bar machines made by Lucas' parent firm, The New Britain Machine Company. The recently introduced XXH size has enabled Lucas engineers to design a simpler, more compact "Timing" Belt drive for their largest machines.

Approximately 2½ times larger and 2½ times stronger than the ½"-pitch "Heavy Duty" series, the "Double Extra Heavy Duty" belt now, for the first time, enables machine designers to incorporate into drives up to 1000 hp the many advantages which have made the "Timing" Belt *industry's most versatile and most desirable form of power transmission.* For more details, contact your nearby NYB&P-Gilmer Distributor or write us direct.

**Lucas Machine Division, The New Britain Machine Co., Cleveland, O.*

Gilmer V-BELTS AND "TIMING®" BELTS

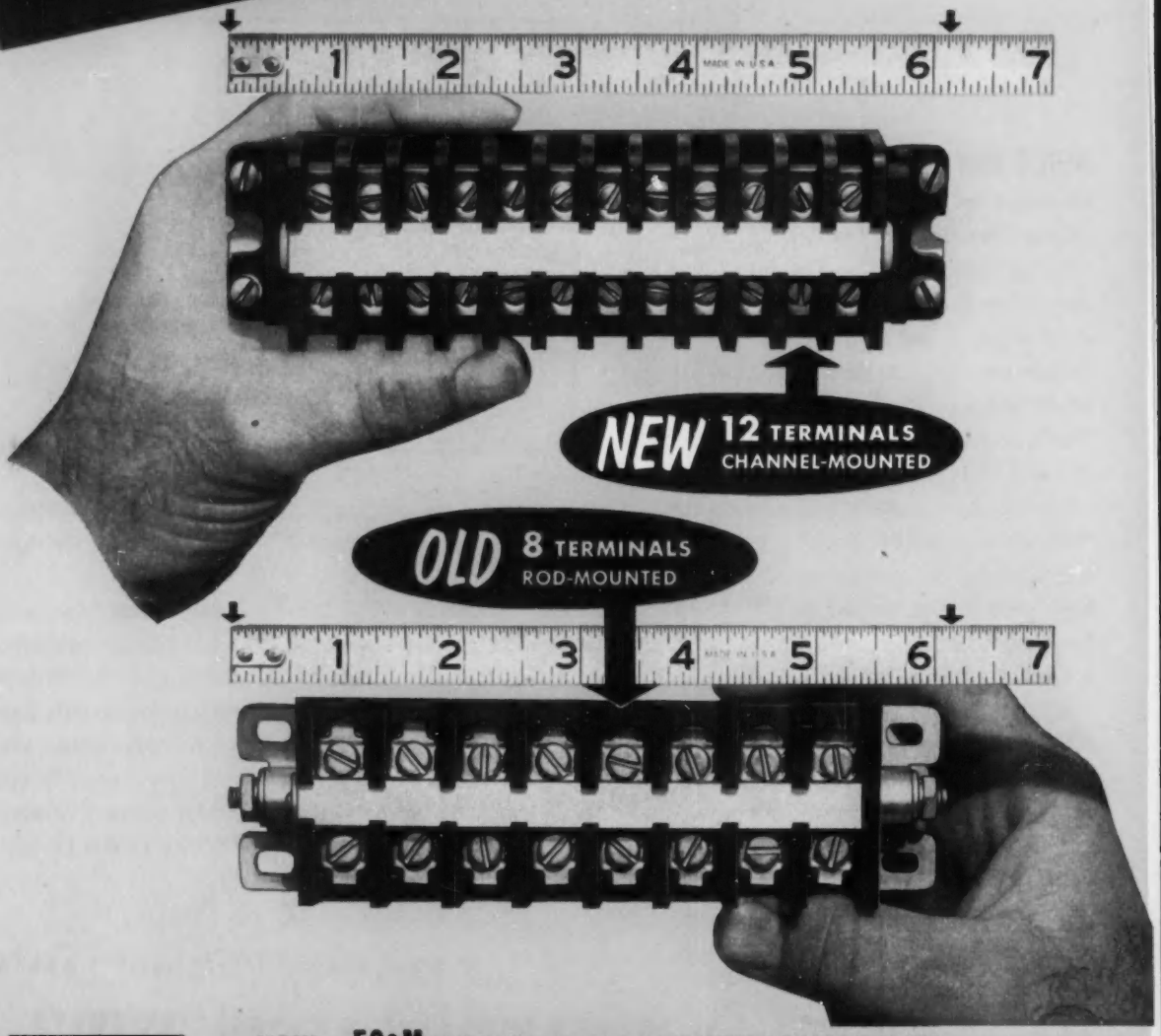
NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

SQUARE D's NEW TERMINAL BLOCKS

50% MORE

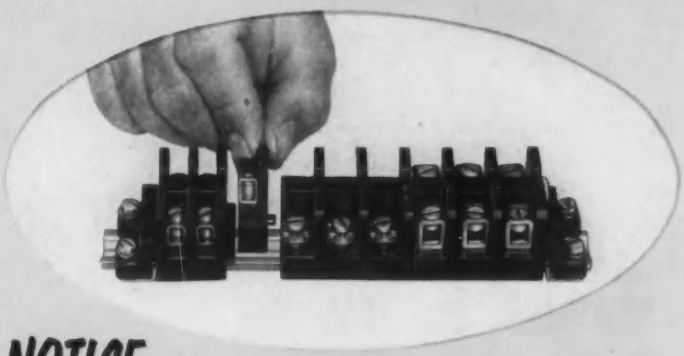


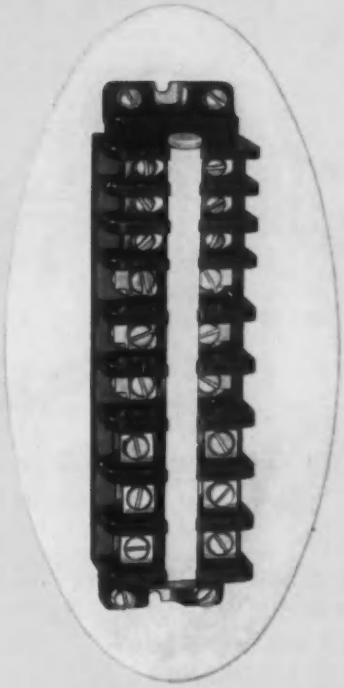
NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

TERMINALS IN SAME SPACE!

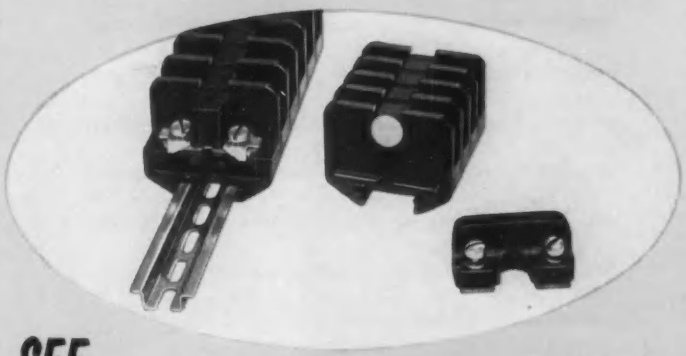
MORE FLEXIBILITY, TOO!





NOTICE (ABOVE) how little space is required to remove or add a Square D channel-mounted terminal block to the completely assembled unit. Especially important for a *QWIK CHANGE* when an additional terminal must be inserted into grouping.

LOOK (AT RIGHT)...all sizes can be mounted on same channel... 25 ampere pressure wire connectors, 25 to 50 ampere box lugs... all can be interlocked together. Terminals available in kit form to "do it yourself" or factory assembled to standard specifications.



SEE ...there is only one perforated channel required for either weld or screw-on mounting...available in standard lengths that can be cut "on the job" to fit any length requirement. Eliminates stocking varying sizes.

ASK YOUR SQUARE D FIELD ENGINEER

or Write for

Bulletin which covers details on Channel-Mounted Terminal Blocks. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.

Everybody's Ahead with Square D!

PRECISION-MOLDED INDUSTRIAL PARTS

with . . .

CYCOLAC®

New HIGH-IMPACT THERMOPLASTIC RESIN

Tremendous Resistance to Wide Variety of Acids, Alkalies, Salt Solutions and Oils!

THE PERFECT RESIN FOR THE MANUFACTURE OF ANY PRODUCT THAT DEMANDS . . .

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- High Heat-Distortion

Get the Facts...

Write Today for TECHNICAL LITERATURE

It's good business to use molded industrial Cycolac parts for valves, fittings, acid baths, connectors and insulating uses. CYCOLAC with its high impact strength, toughness, non-corrosive nature is resistant to a wide variety of acids, alkalies, salt solutions and oils. CYCOLAC has wide temperature range of usefulness; outstanding electrical properties plus excellent dimensional stability.

Marbon

MARBON CHEMICAL

Division of BORG-WARNER

GARY, INDIANA

MARBON CHEMICAL . . . ***Precision Resins for Precision Made Products***

Harrison Oil Coolers Take the Heat off Heavy-Duty Diesels!
Heat abandons ship . . . when Harrison's aboard! With a payload of 30 tons of halibut, it takes a mighty Detroit Diesel engine to power this fishing boat. And it takes a Harrison oil cooler to do the cooling job *and do it right!*
HARRISON KEEPS THIS TRAWLER COOL!
In fact, you'll find Harrison heat exchangers *in every line of industry . . . in every line of defense!* That's because you can depend on Harrison, with over 46 years' experience in design, research and manufacture, for top-quality heat-control products. If you have a cooling problem, look to Harrison for the answer.
HARRISON RADIATOR DIVISION,
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TEMPERATURES MADE TO ORDER
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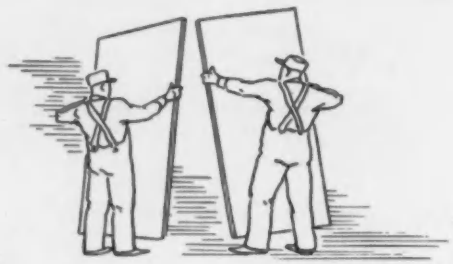
Watch "WIDE, WIDE WORLD" Sundays on NBC-TV
HARRISON



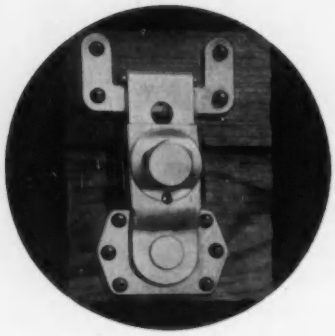
Have you a similar fastening problem?

How a strong structure can be designed for speedy and simple assembly with unskilled labor, no special tools...

The U. S. Air Force wanted a jet-aircraft hangar design that would be portable by air, yet strong; would assemble quickly; be interchangeable, and flexible enough for easy structure modification.

The answer lay in a panel structure using modular units. Armorply honeycomb panels faced with thin aluminum, developed by United States Plywood Corporation, provide lightness, strength, flexibility. Joining one panel to the other in the field with untrained help was a problem until Simmons Fastener developed LINK-LOCK, a simple latching device that operates with minimum wrench pressure on hex nut.

This fastening problem is being successfully met by combining the design ingenuity of No. 1 LINK-LOCK with the proved performance of honeycomb plywood panels.



No. 1 LINK-LOCK—like No. 2 LINK-LOCK—features simplicity, positive action, high strength.

No springs are used in No. 1 LINK-LOCK. Locking action is obtained by rotating a nut that moves a sliding latch in and out of position. Up to 1500-lb. pull-down pressure is available; the device carries up to 4000-lb. tension. No. 1 LINK-LOCKS provide for surface mounting, simplifying installation.

Where can you use it? When you need heavy fastening pressures, resistance to impact, operation in 70-below temperatures—and where ease of action, compactness, and low cost are important factors. Write for a No. 1 LINK-LOCK Data Sheet.

SIMMONS FASTENER CORPORATION
1751 No. Broadway, Albany 1, New York

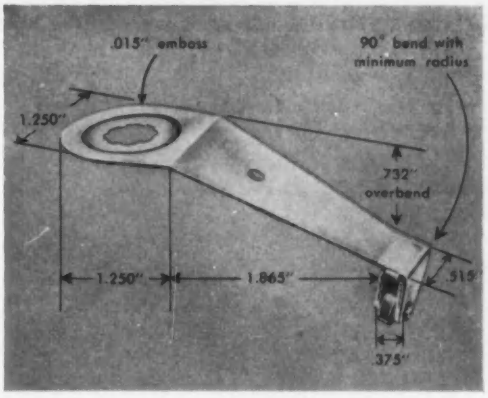
Simmons

LINK-LOCK
QUICK-LOCK
SPRING-LOCK
ROTO-LOCK

FASTENERS THAT IMPROVE PRODUCTS AND REDUCE ASSEMBLY COSTS

This railroad runs better, will last longer

A Type ZW Lionel Trainmaster Control has four independent variable voltage circuits, can operate four trains simultaneously.



One of the four variable voltage taps in a Type ZW Lionel Trainmaster Control, now made of .0150" thick Duraflex in spring temper. This temper in Duraflex provides the extra strength needed—with the same forming properties as conventional phosphor bronze in extra hard temper.

Lionel switched to DURAFLEX for the hardest working parts of its Trainmaster controls

Much of the fun of model railroading depends on the smooth, dependable performance of its controls. That's why Lionel makes its Trainmaster controls tough, precision instruments – constantly guards their quality.

Lionel had been using an ordinary phosphor bronze in the vital, hard-working variable voltage taps. But they were troubled with fractures in forming the bends. To maintain their quality standards, they considered using another alloy, at substantially increased cost.

First, however, they tried Duraflex*, Anaconda's new superfine-grain phosphor bronze. The fractures were eliminated. The press room found the forming qualities of Duraflex excellent. The Transformer Department was pleased with the reduction in rejects, found the strength and resilience better.

So Lionel has controls of superior quality – at no extra cost – for Duraflex costs no more than ordinary phosphor bronze.

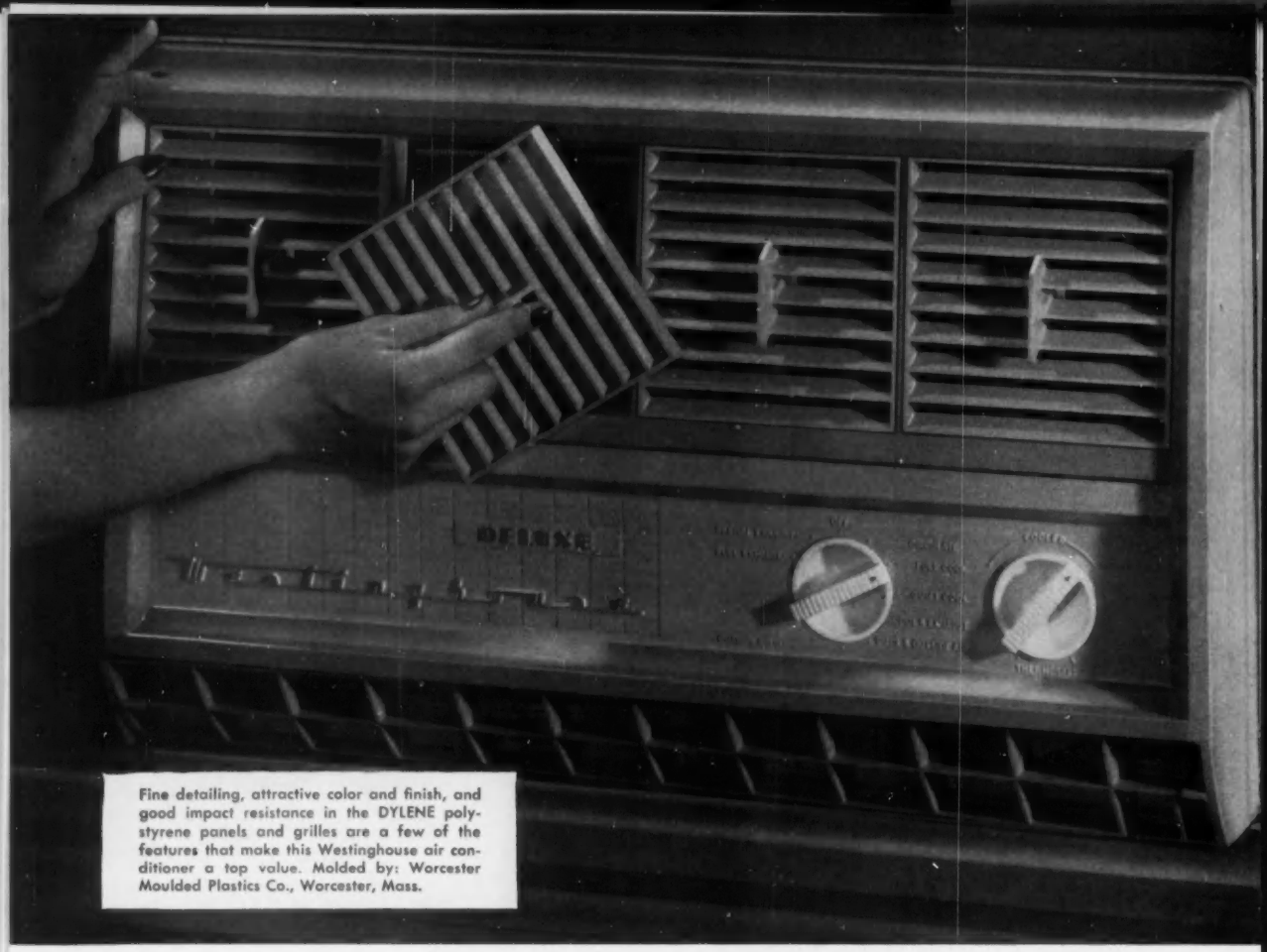
Duraflex, because of its superfine-grain structure, offers greatly improved fatigue resistance and formability. It also has a finer, smoother, harder surface, plus good electrical conducting properties and high corrosion resistance. It is produced in sheet metal up to 0.062" thick and in wire up to 3/16" diameter. We will provide free samples for test purposes – specify gage and temper. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

*Trade Mark

DURAFLEX

The New Superfine-Grain Phosphor Bronze with 30% Greater Endurance Limit

an ANACONDA® product



Fine detailing, attractive color and finish, and good impact resistance in the DYLENE polystyrene panels and grilles are a few of the features that make this Westinghouse air conditioner a top value. Molded by: Worcester Moulded Plastics Co., Worcester, Mass.

Westinghouse makes sure . . . with **DYLENE®** polystyrene

Finely detailed lettering and design—clean, smooth panel edges—attractive colors—glossy finish and resistance to impact. All of these qualities are found in the polystyrene panel and louvers of the Westinghouse Deluxe Air Conditioner. They are notes of quality that help this product live up to Westinghouse's famous "You can be sure . . ." slogan.

DYLENE polystyrene plastic was chosen as the molding material for several good reasons. It molds easily and sets up fast. DYLENE allows use of fine details such as the ⅛-inch-high raised lettering, and it resists cracking or chipping when the spring-held louvers are allowed to snap into position. DYLENE is colorful and has a finish that is attractive to both touch and sight. No wonder it is used by one of the country's foremost makers of appliances. You, too, can make sure with DYLENE polystyrene.

Koppers also produces DYLITE® expandable polystyrene, DYLAN® polyethylene and SUPER DYLAN* polyethylene. For more information on any of these four fine plastics, write to Koppers Company, Inc., Chemical Division, Dept. PE-116, Pittsburgh 19, Pennsylvania.

Koppers Trademark

KOPPERS

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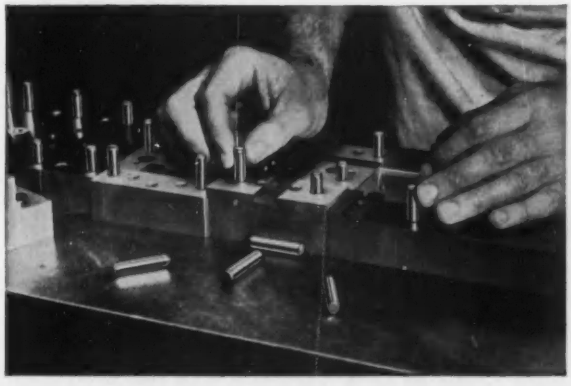
"STOCK ANSWER"
to many a design problem

ALLEN DOWEL PINS

ALLEN DOWEL PINS are being profitably employed in a thousand and one ingenious ways beyond their conventional applications in tool and die work — as economical roller bearings, as axles, precision plugs, hinges and wrist pins to name a few.

If you have an application that will utilize the great strength, accuracy and fine finish of Allen Dowel Pins, you can save substantially on the cost of your product — because you can secure them at favorable prices right from your Allen Distributor's stock.

Check the quick facts at the right and write directly to Allen's Engineering Department for further technical information.



SPECIFICATIONS

- Made from Allenoy heat treated steel. Surface hardness 62-64, Rockwell C scale; core hardness 52-54. Case depth .010″ to .020″ depending on size.
- Single shear strength 160,000 to 180,000 p.s.i.
- Surfaces precision ground to ± .0001″ with micro-inch finish of 6 RMS max.
- Sizes: Diameters, ⅛″ to 1″. Lengths, ⅜″ to 6″.
- Two standard oversizes — .0002 for press fits between mating parts, or .001 for repair work, or holes machined oversize.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.

Control Problems?...Consult CONTROL EXPERTS

Control for Every Industry...Designed by Allis-Chalmers

THE world's largest line of major industrial equipment is produced by Allis-Chalmers. In supplying equipment to all industries, Allis-Chalmers has been called upon to provide every conceivable type of control... STANDARD, MODIFIED and SPECIAL DESIGN... in thousands of applications. This experience can help solve any or all of your control problems... when you specify *Allis-Chalmers Control.*

For Expert Help With Your Control Problems... call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers specialized engineering staffs... by complete research and testing facilities.

For further information call your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

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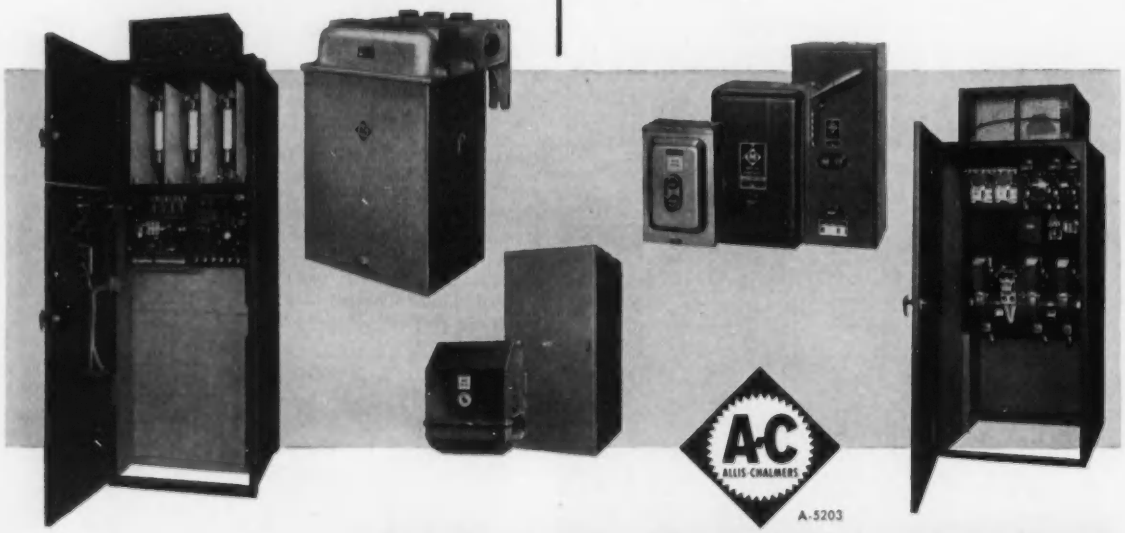


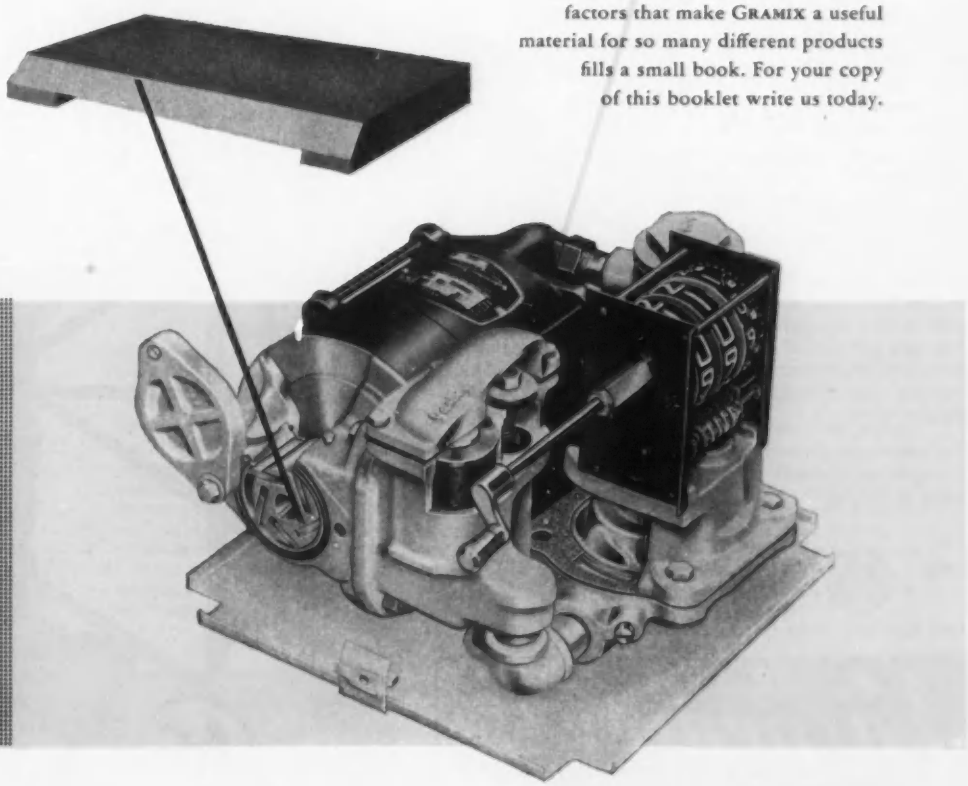
A-5203

ALLIS-CHALMERS

GRAMIX® vanes in Gasboy® pump wear only .031" per ONE MILLION GALLONS

The Gasboy Super "200" gasoline pump is manufactured exclusively for farms, fleets, and industry by Wm. M. Wilson's Sons, Inc. in Lansdale, Pa. These pumps have proven to be accurate, efficient and dependable. But, what naturally interests us and will interest you, as a manufacturer or designer, are the GRAMIX vanes in these pumps. Tests reveal that the GRAMIX Grade 41 vanes still operated perfectly after pumping over 1,000,000 gallons of gasoline. During this endurance test, the vanes travelled around the inside of the housing a distance equal to 13,000 miles, or more than half way around the earth!

Not only these particular vanes, but hundreds of other GRAMIX parts are doing a successful job in appliances, aircraft, automobiles and an amazing variety of products. GRAMIX parts are die-pressed to close tolerances, and need no machining. They are strong, they are self-lubricating. The many factors that make GRAMIX a useful material for so many different products fills a small book. For your copy of this booklet write us today.



116

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Concentrated Heat for Industry*

Scientists and engineers have done a tremendous amount of work, over the past 10 years, with new techniques in burning fuels. Most of their work has been aimed at the goal of making airplanes and rockets fly faster. Now, as this illustration shows, industry is picking up some of the techniques for its own use.

and smaller area can pay off in the operations of several industries. But as it stands, a jet turbine's ... too rich for a ple... bine's f...

*from BUSINESS WEEK of January 22, 1955

...built around *Carpenter* Stainless Tubing for Long Life!

This unique type compact heat exchanger has found ready acceptance as a highly efficient and dependable source of hot air or gas at pressures up to 300 psi and temperatures to 1200°F. Carpenter Stainless Tubing met every requirement of the manufacturer—superior strength at high pressures and temperatures, easy fabrication, uniform expansion, oxidation resistance and long, maintenance-free performance. That's why Carpenter Stainless Tubing is used exclusively for the straight tube and coiled fin-tube bundles, both shown at right partially assembled.

Any heat transfer equipment worth building or using is worth Carpenter quality. It costs no more . . . because all full-finished Carpenter Stainless Tubing meets the high and uniform quality requirements for heat exchanger applications. And you are sure of getting the highest possible degree of perfection in Carpenter tubing because it must pass the most exacting and thorough non-destructive test ever applied to stainless tubing.

Call your nearest Carpenter Distributor or Branch Office to give your equipment the benefit of better-than-ever Carpenter Stainless Tubing.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

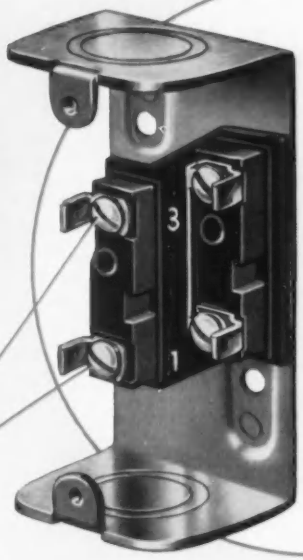
Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

Brand New Idea in STANDARD-DUTY STATIONS

THE CONTACT MECHANISM IS IN THE COVER!



THESE ARE THE WIRING TERMINALS!

EASIER TO WIRE!

No skinned knuckles

No cramped wiring space

Here's an entirely new idea in push button stations—a wrap-around cover—with the contact mechanism part of the cover. Removing the cover exposes the terminals for instant and easy wiring. Strong, spring type, silver plated contacts connect the push button assembly in the cover with the terminals in the base.

Matching ribs in the cover and notches in the terminal blocks assure that the wiring connections are always correctly made. A bakelite shield protects the contact mechanism and prevents careless wiring from interfering with the contact operation. Concentric knockouts are provided in both top and bottom of the heavy metal base.

You will want to know about this new standard-duty station because—it is good looking—it takes less time to install—it was designed for the convenience of the installation engineer.

Let us show you a sample of this "brand new idea" in standard-duty stations!

A-B Quality

ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ontario

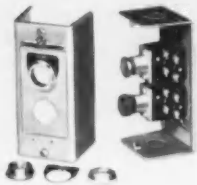
Bulletin 800 standard-duty push button stations can be supplied with one, two, or three buttons, or as a selector switch. Also available with pilot light. Furnished only in NEMA Type 1 enclosures.

9-56-MR

Also... ***NEW*** **HEAVY-DUTY PUSH BUTTONS**

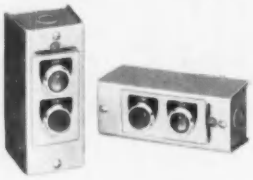
BULLETIN 800

NEW FLEXIBILITY!



You can assemble any special heavy-duty station from a small stock of standard push button, selector switch, and pilot light components. There is no need to wait for long delivery of your special stations.

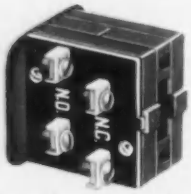
Stations can be arranged for either vertical or horizontal mounting. Name plates can be rotated to any position, replaced with any standard marking, or removed entirely.



NEW ENCLOSURES!

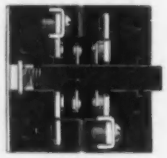
Each button, selector switch, or pilot light is a self-contained unit which can be mounted in attractive new enclosures. Standard enclosures accommodate up to eight units, but enclosures can be furnished for larger numbers.

NEW CONTACT BLOCK!



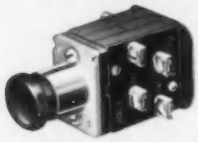
Above: View of contact block, showing terminals for normally open and normally closed contacts. Right: Contact block, with cover removed, showing stationary silver alloy contacts and pushrod carrying the moving contacts.

Bulletin 800 heavy-duty push buttons have the same molded contact blocks that have proved so dependable in Bulletin 800T oiltight push buttons, although they are not themselves oiltight. And all of them are equipped with double break, silver alloy contacts.

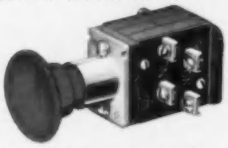


NEW OPERATORS!

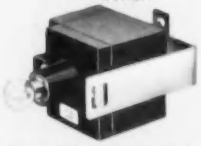
Operators, which mount on the contact block, are available in many types, and push buttons come in various colors.



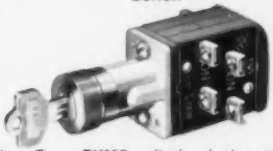
Type AK2B flush head START button



Type DK6A mushroom head button



Type PK16 pilot light with transformer



Type EK11B cylinder lock unit

9-56-MR

A-B Quality

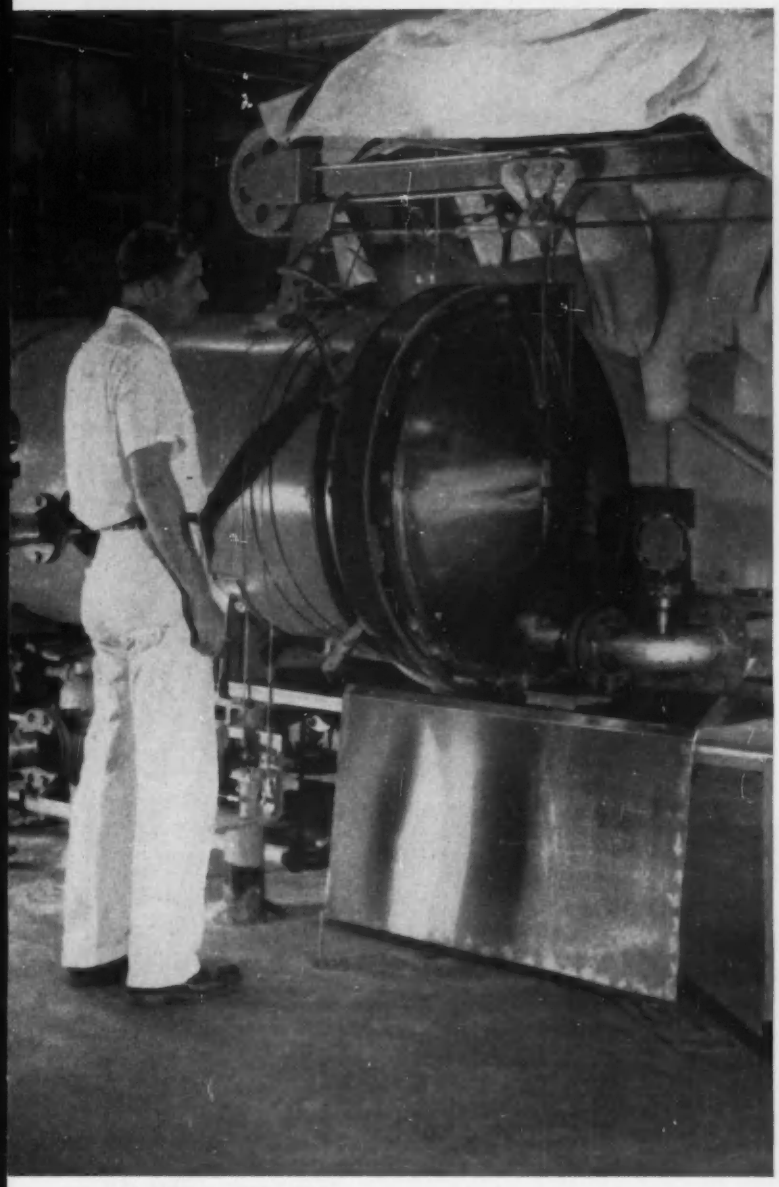
ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. In Canada—Allen-Bradley Canada Ltd., Galt, Ontario

NOTHING *can equal Stainless Steel*



FOR CORROSION RESISTANCE. The Norwich, N. Y. plant of Norwich Pharmacal Company is a magnificent display of Stainless Steel. Shown here is a Stainless Steel filter, used to separate mother liquor from the solids of furoxone. Here, Stainless outlasts any other practical metal by two to one.

No other design material can match Stainless Steel in its *combination* of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When buying Stainless, remember that United States Steel offers the widest range of types, finishes and sizes available in the United States.

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

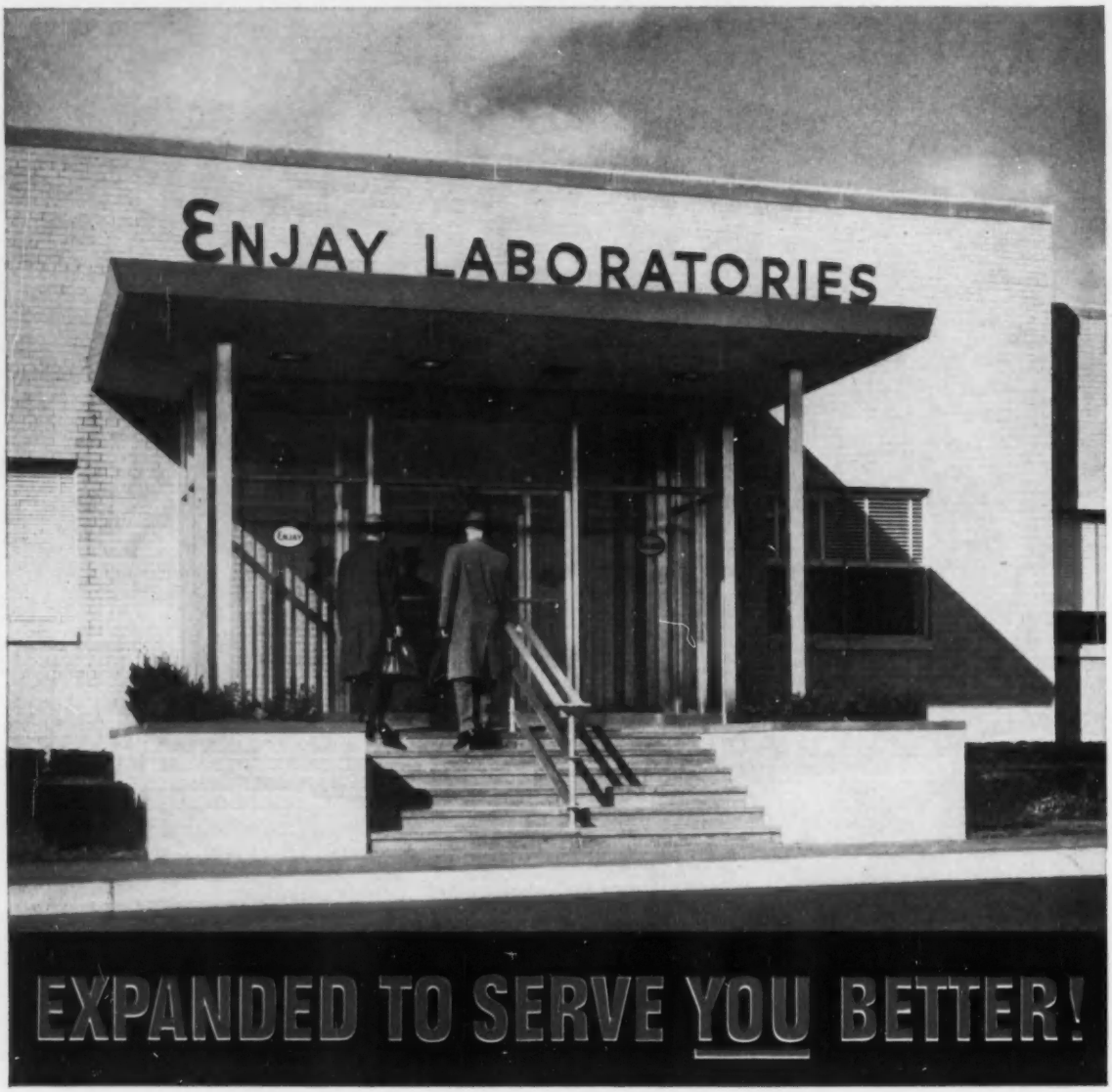
FOR EASY CLEANING. In this textile plant of W. J. Dickey & Sons, Inc., dyeing time *and* costs have been cut 50% with the use of Stainless Steel equipment. When colors are changed, tanks don't have to be boiled out. With its smooth, dense surface, Stainless can be cleaned easily and quickly.

FOR CONSUMER APPEAL. Now, just about every housewife knows what Stainless Steel is. When she sees the Stainless tub in this automatic laundry, made by Speed Queen Corp., Ripon, Wis., she knows that there is nothing to corrode. She knows, too, that the Stainless tub will stay bright and clean and will last forever.

USS

UNITED STATES STEEL

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALABAMA • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK



EXPANDED TO SERVE YOU BETTER!

The Enjay Company proudly invites you to inspect the new polymer wing of the Enjay Laboratories, located in Linden, N. J. Continuing the tradition of pioneering in petrochemicals, Enjay has built this new laboratory addition for application research and development exclusively in the polymer division.

With the latest technical equipment and top scientific talent, this new laboratory enables the Enjay Company to give the best possible product application service, as well as furthering Enjay's own product research program.

High speed electronic data processing equipment helps the Enjay scientists solve your compounding problems in record time. In developing new products, or improving old ones, call on Enjay for top-notch assistance. Contact your Enjay representative for further information.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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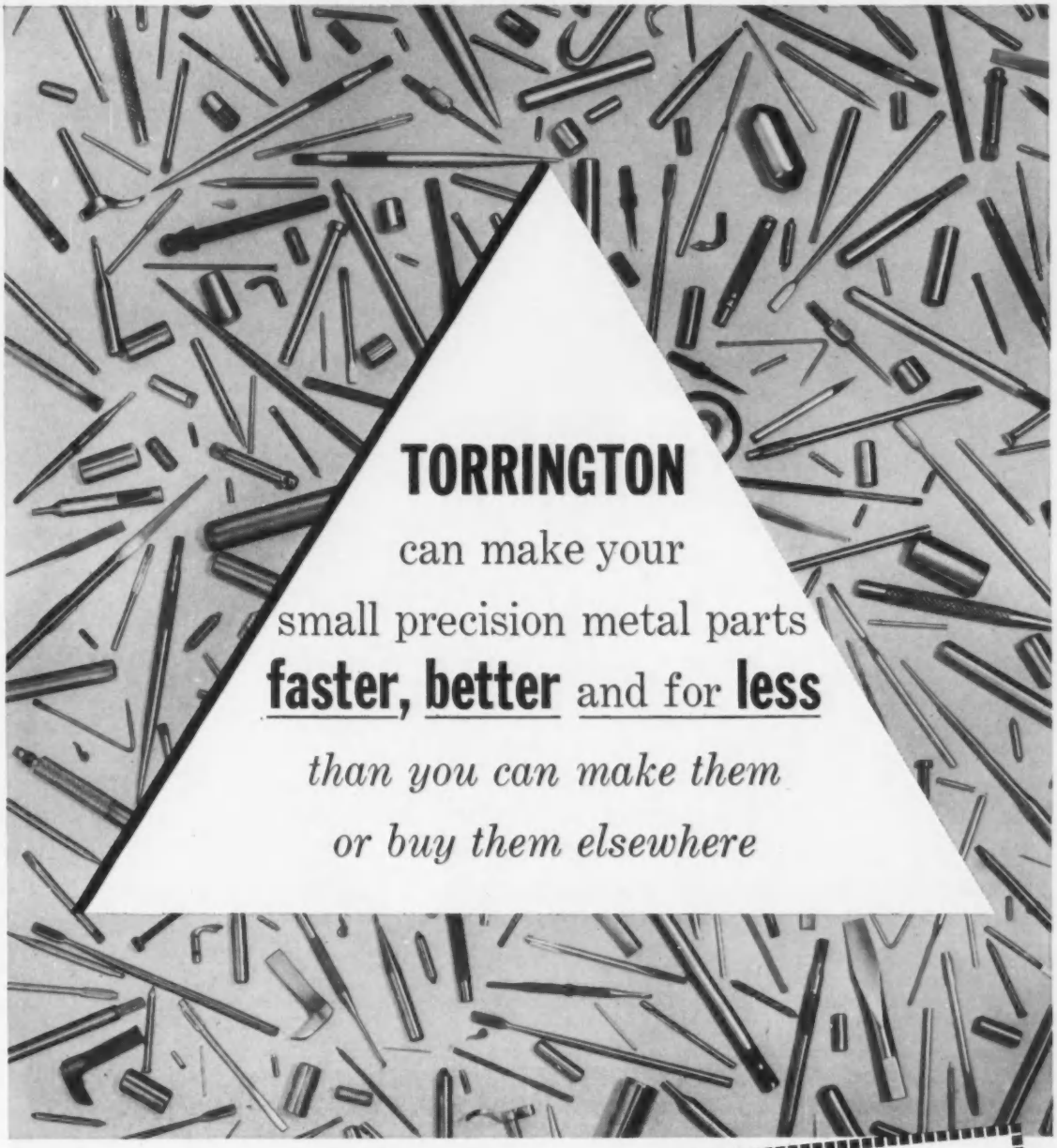

These are typical of parts that Torrington produces daily by the hundreds or millions. If you use similar small precision parts, mail the coupon today for the Torrington Small Precision Parts condensed catalog. Even better, send a sketch, blueprint or sample part. We will give you a prompt quotation which will mean substantial savings to you.

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Specialties Division
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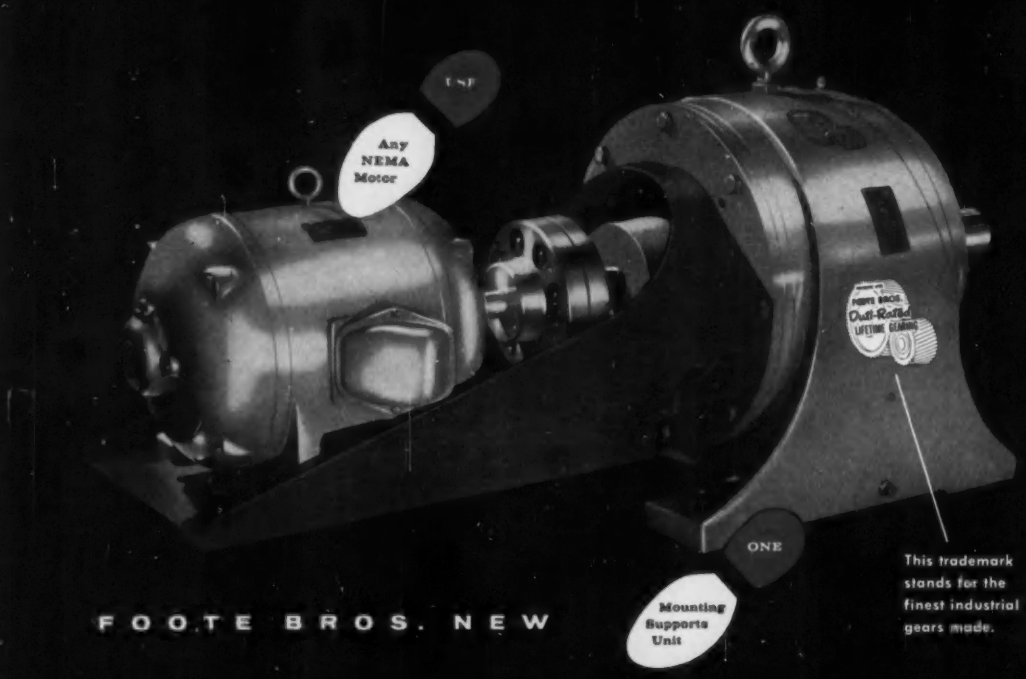
Basic Idea

SOLVES MANY REDUCER MOUNTING PROBLEMS



This trademark stands for the finest industrial gears made.

FOOTE BROS. NEW

Line-O-Motor Drive

One base supports both speed reducer and motor in this simple, practical and foolproof mounting system . . . Now you can use standard N.E.M.A. motors and make change-overs in minutes—reducing both costly down-time and motor inventory.

Line-O-Power motorized drive solves many old problems . . . and opens new fields of advanced design for new applications. Available 1-75 H.P. for all Service Classes—Horizontal, Vertical, and Vertical Extended with Foot or Flange mounting—Double or Triple Reduction units available in Ratios from 5.06:1 to 238:1.

FOOTE BROS.

Better Power Transmission Through Better Gears

4545 S. WESTERN BLVD., CHICAGO 9, ILLINOIS

Dept. W

Write for your Line-O-Motor Catalog today

Designer Nathan Roop talks plastics:

"In the early days, we felt that plastics could be used to create anything at all. Today, we have more practical knowledge of what we can do best . . . and how," states Nathan W. Roop, Chief Designer, Columbus Plastics Products, Columbus, O. "Originally, many people were rather unfair to plastics. Metal dents, and glass breaks . . . yet the public, accustomed to this over the years, has learned to accept the limitations innate in certain materials. Plastics, on the other hand, were expected to be absolutely perfect! This means that we have had to achieve more within our marketable forms than manufacturers in other materials. The fact that we have done so, despite unreasonable expectations, is proven by the industry-wide expansion that has taken place."

Mr. Roop designed the Lustro-Ware Step-On Can shown here. This item won the "Best of Competition" award in the 1956 Koppers Annual Design Competition. In the past seventeen years, he has played a major role in designing and producing nearly three thousand different molded plastic parts.

"One of the factors responsible for advances in the plastics field can be traced to demands by housewives for particular items." Roop felt that, "Another factor is the tremendous advances made in composition of plastic material. Once limited to acetate and butyrate, we now have high-impact styrene, polyethylene, and other compounds which have enabled us to turn out a wider range of superior products."

Koppers furnishes the plastics industry with these four fine plastics: DYLAN® polyethylene, SUPER DYLAN* polyethylene, DYLENE® polystyrene and DYLITE® expandable polystyrene. For more information on any of these plastics, write to Koppers Company, Inc., Chemical Division, Dept. PE-116, Pittsburgh 19, Pennsylvania.

Koppers Trademark

HIGH-IMPACT OUTER SHELL

KOPPERS

KOPPERS PLASTICS

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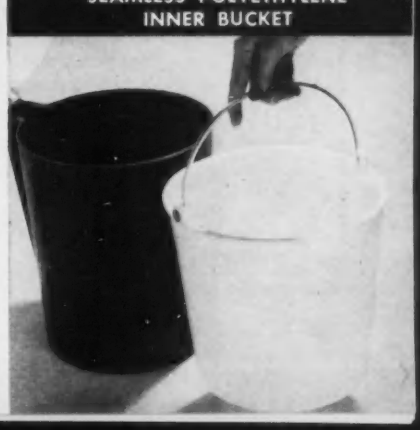
In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

STEP-ON, LID-RAISER

STAY-OPEN HINGE

SEAMLESS POLYETHYLENE INNER BUCKET



SET TO GO!

265 Westinghouse warehouses
stock the *Life-Linestarter* ...

Here it is. The most advanced starter on the market. And it's ready for immediate shipment. Available in a uniform and complete line backed by Westinghouse application and service facilities. The Life-Linestarter* is the starter you can install and forget.

Among its outstanding features are De-ion® arc quenching and the exclusive knife-edge bearing design which greatly reduces friction and wear. You are assured of long life, ease of installation and maintenance, and instant, positive motor protection.

Get this magnetic motor control by calling your Westinghouse sales engineer and placing your order. Call him today. *Trade-Mark

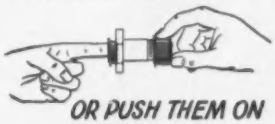
J-21929-X

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

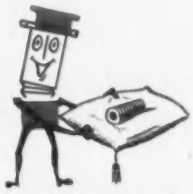
SLICK, QUICK WAY TO KEEP A PRODUCT SAFE AND SOUND IN PROCESS, STORAGE AND TRANSIT

JUST PUSH THEM IN

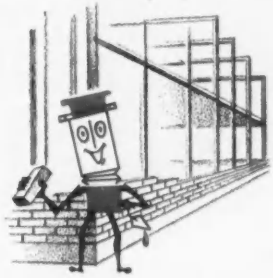


OR PUSH THEM ON

Tapered CaPlugs can be used as caps or plugs on threaded or plain fittings... save up to 500% in labor costs



ESPECIALLY KIND TO THREADS AND POLISHED SURFACES



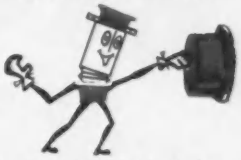
CAPLUG engineering, research, and warehouse facilities expanded to meet growing demands of thousands of industries

8 STANDARD DESIGNS AND 300 STOCK SIZES FOR EVERY NEED
TAPERED CAPLUGS
CAPS & PLUGS FOR ELECTRICAL FIXTURES
SEAL & SHIPPING CAPS
THREADED PLUGS
TUBING SLEEVE CAPS
THREADED PIPE PLUGS
TUBING PLUGS
TAPERED CAPLUGS WITH WIDE HEAVY FLANGES

TOUGH, FLEXIBLE

CaPlugs

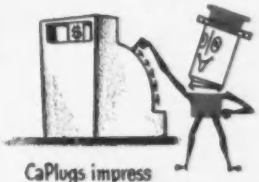
MADE FROM STUFF THATS ESPECIALLY TOUGH



Molded of flexible Polyethylene, CaPlugs are impervious to most common chemical reagents, acids and solvents... will not collapse, chip, break or shred

AN ALMOST ENDLESS LIST OF USES

GIVE A PRODUCT "BUY APPEAL"



CaPlugs impress the customer with the steps taken to protect the equipment

GET THIS FREE "SEE-FOR-YOURSELF" *ASSORTMENT BY MAILING THIS COUPON*

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2205-9 Elmwood Ave., Buffalo 23, N.Y.

Mail a free assortment of CaPlugs, literature and prices to us immediately without obligation

NAME _____ TITLE _____

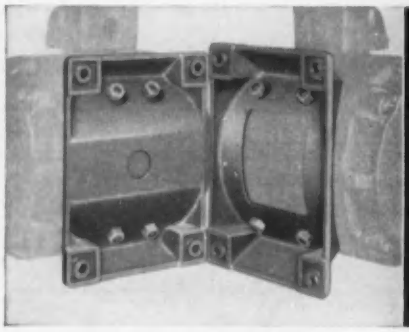
FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

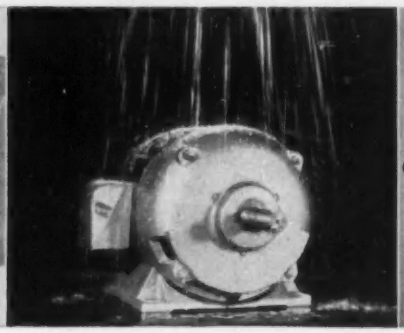
Single-Phase EXCLUSIVE ...totally-enclosed motor switch and actuator... in

You get these quality A. O. Smith motor features...



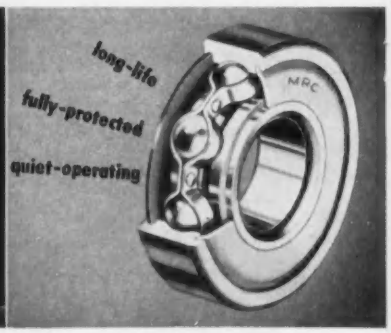
OPTIONAL FRAME MOUNTINGS

There's no need to change product design to use new NEMA frame sizes. A. O. Smith gives you frame mountings drilled to old and new specifications.



DRIP-PROOF CONSTRUCTION

Motor can be mounted in any position . . . drip-proof thru 360° cycle . . . simply rotate end brackets. No foreign matter can enter vent holes.



PRE-LUBRICATED BEARINGS

Shielded bearings assure protection against over greasing . . . provide even load distribution under all working conditions . . . quiet operating.

A. O. Smith integral hp motors

* Always clean

* Easy to service

THE secret of the totally-enclosed switch assembly is a sealed pocket in the end bell of the motor . . . a recess designed specifically to house the entire switch and actuator assembly. The pocket is then sealed with a cork-lined cover to prevent any type of dirt, dust or other foreign matter from *ever* coming in contact with these critical parts.

Service is a cinch. Because of the proven simplicity of the A. O. Smith switch design, service, even without the separately sealed feature would be practically nonexistent. Each switch is individually adjusted to the precise setting for long life and best electrical performance. As a result, it's almost impossible for contacts to burn out.

When you specify A. O. Smith integrals, you get motors that are application-engineered to match your particular product design. There's no need to adapt your product to the design limitations of conventional motors.

And remember — for your design or speed requirements, there's an A. O. Smith integral hp motor available to power your products. Integrals are built in a single-phase (1 thru 7½ hp) and polyphase (1 thru 150 hp) . . . in various speeds and frequencies . . . choice of frame mountings for either old or new NEMA dimensions . . . C and D flanges or special flanges as required.

Produced by one of America's great industrial concerns, these motors are backed by a national network of 270 strategically located factory service stations. There's one near you—ready to provide 24-hour service on all parts and service orders.

For more information on A. O. Smith integral hp motors, write for new Bulletin No. EM156.

Through research A.O. Smith *. . . a better way*

A.O.Smith

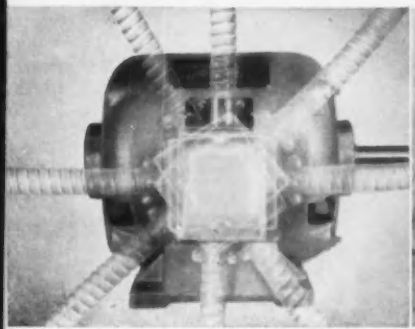
CORPORATION

ELECTRIC MOTOR DIVISION

TIPP CITY, OHIO

International Division: Milwaukee 1, Wisconsin

application-engineered to match your product requirements

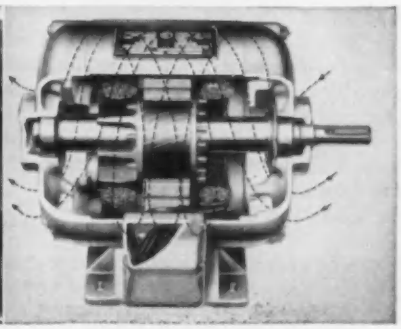


FULL-ROTATING CONDUIT BOX

Can be set at any angle. Designed to save motor space and speed installation. Loosen only three screws to rotate conduit base.

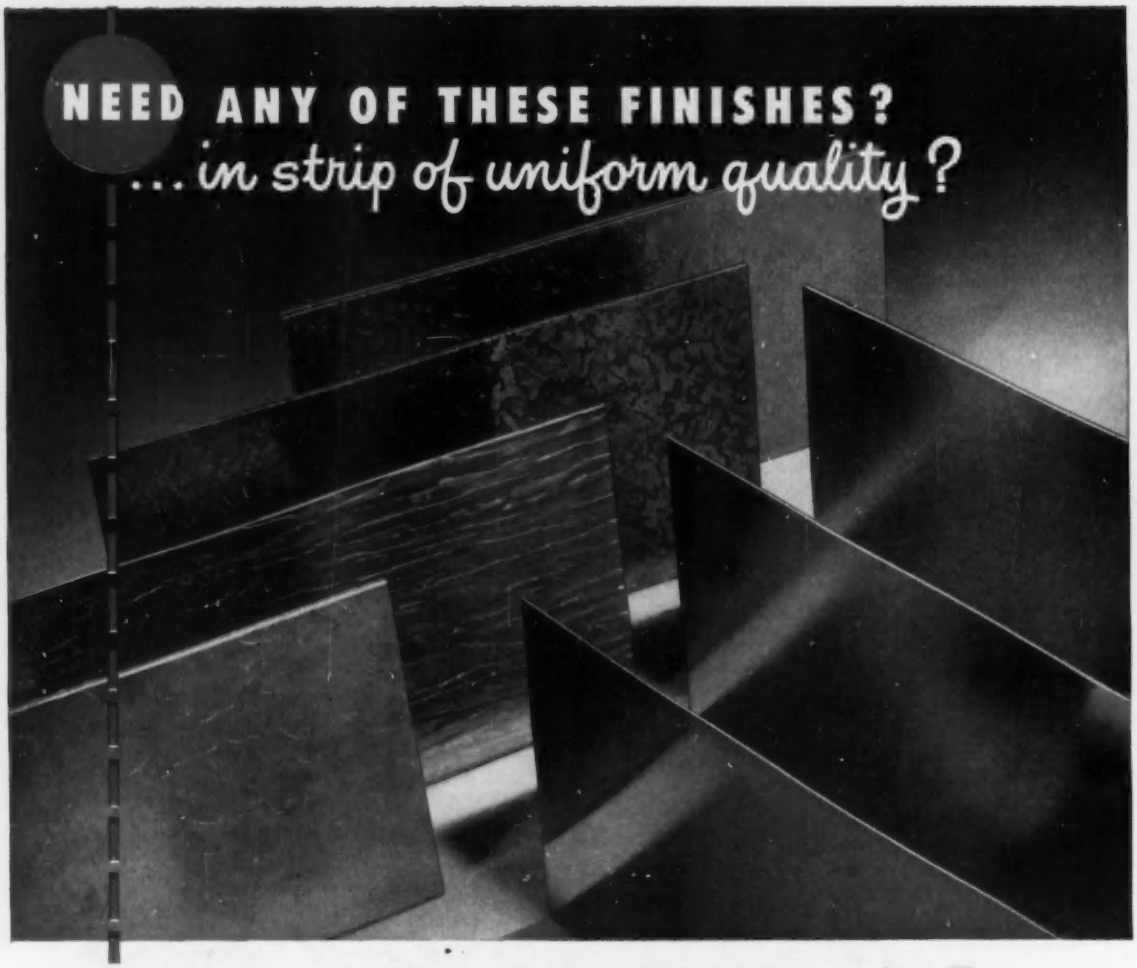
DYNAMICALLY-BALANCED ROTOR

Assures continuous, vibrationless, trouble-free performance and maintains long bearing life. Indestructible laminations are high-quality silicon steel.



CONTROLLED THRU-VENTILATION

Cooling system designed for high-volume, low velocity air for maximum heat transfer. Temperature held to absolute minimum, assuring longer insulation life.



GET AMERSTRIP!

Why buy Amerstrip? Simply this: it brings you a finish tailored to your needs. High quality Amerstrip will minimize reject problems and improve the finished product. These are the best reasons, but not the only ones, for choosing Amerstrip cold rolled strip steel.

The metallurgical care that goes into making the Amerstrip, the even temper that goes with every shipment, also help you cut rejects and costs, help you make steadily improved products of steel.

Amerstrip comes in the widest available range of analyses, sizes, and finishes. You can get it embossed, coated, or in any of the standard finishes.

Specify Amerstrip.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION
GENERAL OFFICES: CLEVELAND, OHIO

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
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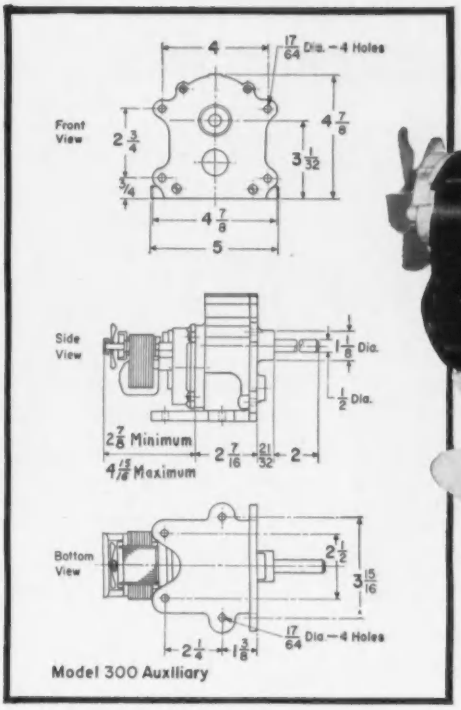
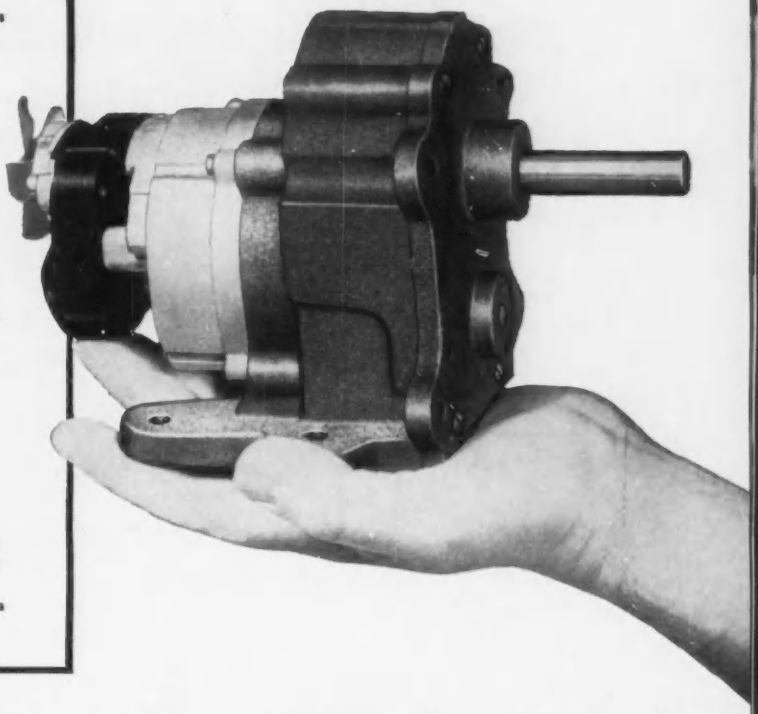
Amerstrip

USS

UNITED STATES STEEL

POWER UNDER CONTROL





Here's a Motor Looking for Work

The newest in the line of Merkle-Korff fhp geared motors is the model #300 shown above. This unit, in continuous duty service, will deliver up to 300 lb. in. torque, yet it fits in the palm of your hand. The motor is ideally suited for applications requiring the operation of heavy cams, cranks or gears mounted directly on the motor shaft.

A typical torque table is shown below. This table shows no-load speeds for uni-directional shaded pole induction motors. The loads are the maximum under which the motor will start and operate continuously without over-load. The range of speeds shown are representative of those most commonly used. If the maximum rated torque is required at speeds greater than shown, modifications can usually be made, or the unit can be furnished at speeds as low as 1 RPH or slower.

This model #300 is only one of a long and varied line of Merkle-Korff fhp geared motors. They range in speed from 800 RPM down to any fractional RPM required. Merkle-Korff motors can be furnished either with induction shaded pole motors, or with synchronous, reversing, series, or shunt wound motors. These motors are furnished in a wide range of horse power ratings depending upon the output shaft torque requirements.

Merkle-Korff engineers will assist your design staff in specifying the unit best suited to your requirements.

TORQUE TABLE
MODEL 300

rpm	stator thickness		
	9/16"	15/16"	1 1/2"
10	25 lb. in.	33 lb. in.	60 lb. in.
8	30	40	75
6	42	54	100
5	50	65	120
4	62	80	150
3 1/2	70	92	170
3	80	108	200
2 1/2	100	130	240
2	125	162	300
1 1/2	166	216	300
1	250	300	"
1/2	300	"	"

MERKLE-KORFF GEAR CO.

219 NORTH MORGAN STREET • CHICAGO 7 • ILLINOIS

EDWIN M. BOND
Box 333, Rumson, N. J.

RALPH D. EARNEST ASSOCIATES
12818 Puritan Ave., Detroit 27, Mich.

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1412 S. Los Angeles St., Los Angeles 14, Calif.

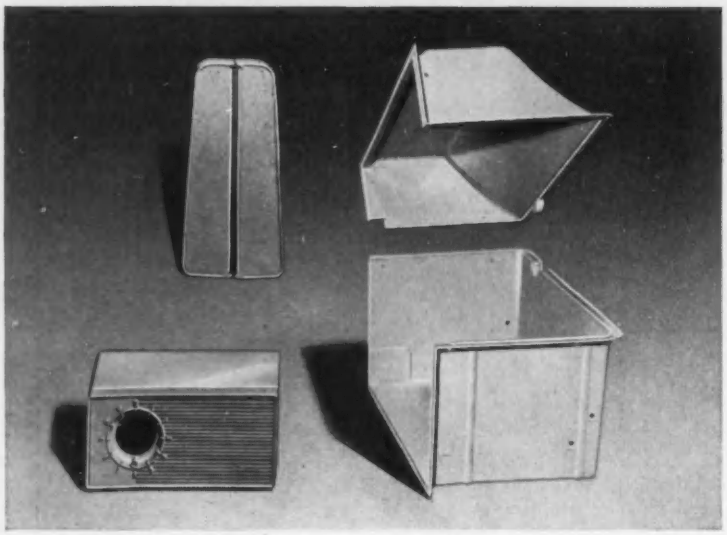
NOVEMBER
1956

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

DOW

THE IMPORTANCE OF CONTROLLED PRESSURE IN PLASTICS MOLDING



Recent developments in controlling plastics pressure have made it now possible to mold large, complex shapes, such as the radio cabinet, refrigerator liner and luggage end caps.

The disposable cup exemplifies the uniform quality product now demanded of materials and processes in fully automatic, high-speed molding. These cups were molded from Styron 689, a new general purpose formulation with greatly improved properties of easy flow.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

A CONTINUING REPORT

Results of Dow Plastics Technical Service research will appear in these pages from time to time. For a complete summary of Dow products and services, write: THE DOW CHEMICAL COMPANY, Midland, Michigan—Plastics Sales Department PL429G.

INJECTION MOLDING RESEARCH SHOWS WAY TO BETTER TECHNOLOGY

In the continuing Plastiatrics studies under the direction of Dow Plastics Technical Service, one of the most rewarding areas of investigation for meeting more exacting needs today has been in the control of plastics pressure.

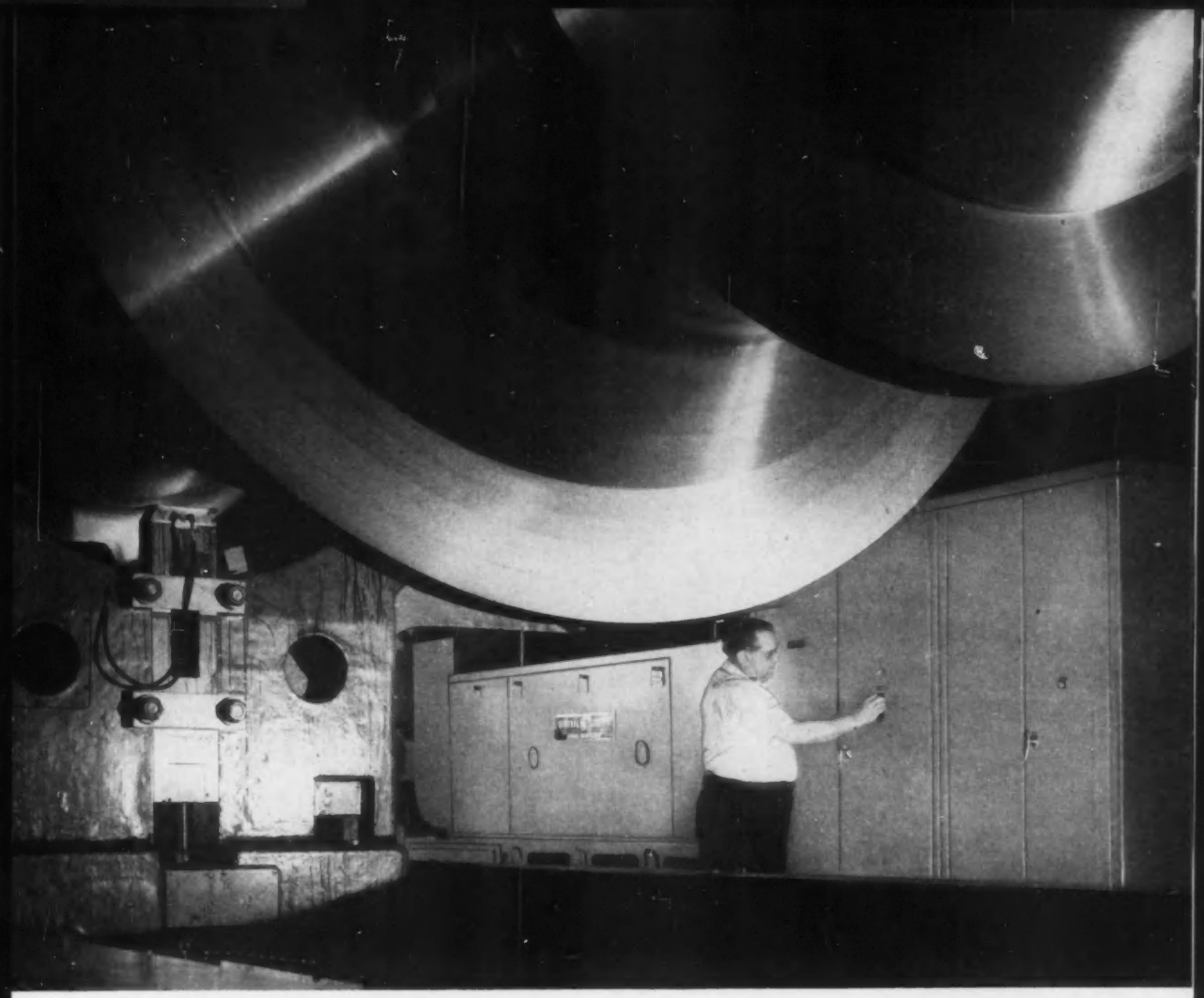
Beginning with the remarkable results of the early "pinpoint gate", considerations for equalizing pressure distribution in the molding system have assumed greater importance. Mechanical aids, such as the "free-flow" and "ball-check" nozzles, were adopted. Thermal studies on the effect of mold heats have made die temperature control units commonplace. Later findings that pressure control is directly related to the accuracy with which granules are fed to the heating cylinder led to the adoption of weigh feeders and pre-plasticizers for top efficiency.

Currently, the heating cylinder itself is a subject of widespread investigation for better conservation of pressure. Studies point to the fact that more efficient designs will greatly improve performance of the molding process. Meanwhile, at Dow the size, shape and treatment of plastic granules to conserve pressure loss have become important considerations in their manufacture. In Styron® (Dow polystyrene) alone four different granulations are offered with or without surface treatments to provide the molder unparalleled versatility in meeting design requirements.

The practical benefits of continuing Plastiatrics studies, such as those on pressure control, result in leadership. In Dow plastics you will find the better quality of materials more meaningful because they are realistically designed to perform for you. Ask for your copy of "Injection Molding Research Today and Tomorrow" or get in touch with your Dow representative for more complete information.

you can depend on
DOW PLASTICS

DOW

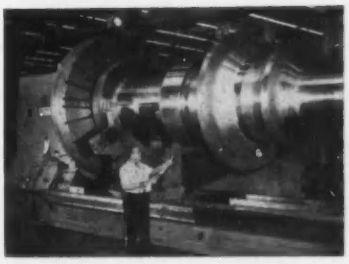


Power and Precision—in a Package

General Electric D-c Drives Supply Power and Close Control for New Lathe

Machining 200-ton workpieces at closely regulated speeds over a wide range demands precise control. To obtain it this giant lathe relies on d-c power supplied by General Electric Speed Variators.

Combining Power and Precision, it can handle jobs 55 feet long, 12 feet in diameter and weighing 200 tons. It is one of the heaviest and most powerful lathes ever built in America.



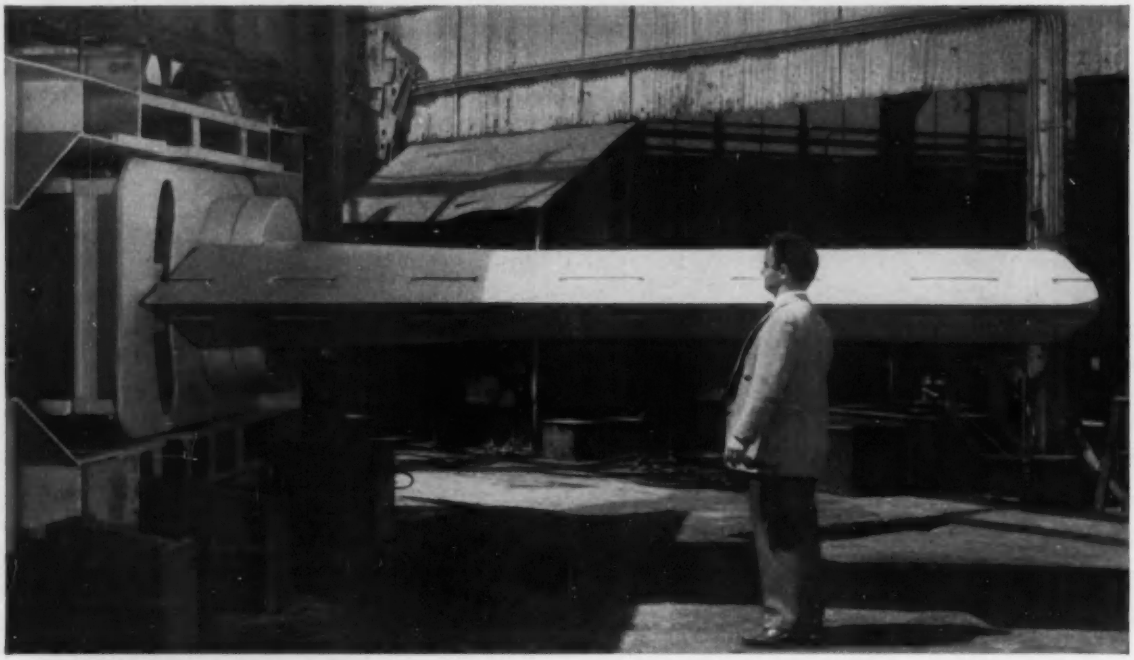
Versatile D-c Power is obtained from the compact Speed Variator power unit installed near the lathe. Containing the motor-generator set and controls in a single cabinet line-up, the power unit supplies direct current for the 200-hp drive motor.

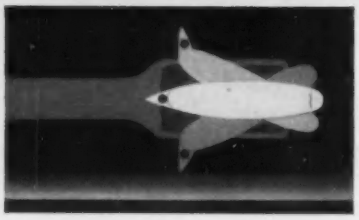
Finger Tip Control, permitting the operator to easily set and hold rotating speeds, is provided by a conveniently mounted push-button station. The accurate control of the speed assures mirror-like surface finishes. The wide choice of speeds provides the flexibility for handling workpieces of varying diameter.

Controlling Heavy or Light Loads with precision and accuracy is characteristic of General Electric Packaged Speed Variators. Providing stepless, motor speed control over wide ranges, these drives are tailored to your particular application by General Electric engineers.

A General Electric Sales Engineer would like to help build this precision into your machines. Why not ask him to call? ***Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.*** 821-4

GENERAL ELECTRIC





Reduces ship roll up to 90% — First commercial installations of the Sperry Gyrofin are on the Matson liners, *Mariposa* and *Monterey*. The design calls for strong, corrosion-resisting Inco Nickel Alloys at key locations: "K" Monel hinge pin . . . Monel nickel-copper alloy spacer rings . . . Monel overlay (welded with "140"* Monel Electrode) on flap control surfaces.

Sketch at left shows the tilting range of the underwater fins that keep a ship steady. One fin extends from each side of the hull amidships.

"K" Monel allows sea water lubrication in new Sperry-designed Gyrofin

See the flap on the fin above?

It's a key part of the Sperry Gyrofin® Ship Stabilizer, a new invention to keep ships steady in heavy seas.

Designing the flap hinge posed two problems for Sperry engineers.

First . . . high strength. A hinge pin was needed that could take its full share of *3,000 foot-tons* of anti-rolling moment.

Second . . . positive lubrication. Almost instantaneous response to computer instructions is required . . . fin (and flap) sometimes change direction *every two seconds*. But how could the hinge area be sealed off and lubricant supplied?

A "K" Monel age-hardenable nickel-copper alloy hinge pin *solved* Sperry's first problem . . . *by-passed* the second.

This rod, 4½-in. dia. by 15 ft. long is strong enough to hold the flap firmly in position as it withstands the battering force of ship and sea. And the exceptional corrosion resistance of "K" Monel permits use of *sea water* as a lubricant . . . eliminates the need for a sealed hinge!

Designing parts for operation in corrosive media?

Or for other destructive service conditions? Investigate the Inco Nickel Alloys. Their properties and applications are described for designers in a helpful booklet . . . "Standard Alloys for Special Problems." A postcard brings your copy.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK **NICKEL ALLOYS**

Monel* • "R"* Monel • "K"* Monel • "KR"* Monel • "S"* Monel
Inconel* • Inconel "X"* • Inconel "W"* • Incoloy* • Incoloy "T"*
Ni-o-nel • Nimonic* Alloys • Nickel • Low Carbon Nickel • Duranickel*

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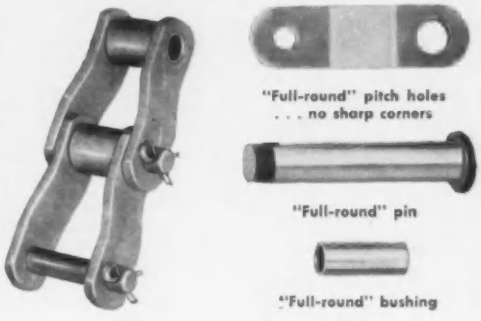
"Stress raisers" eliminated by Link-Belt LXS chain design

LXS "FULL-ROUND" DESIGN



"FULL-ROUND" DESIGN eliminates stress concentration points. Heat treatment of all parts adds even greater strength and extra wear life to selected steels. Accurate control of these processes avoids brittleness, poor wear values and low tensile strengths . . . and assures uniformity.

Large pins, bushings mean ample live bearing area for long life

For long life under severe conveyor and drive conditions, Link-Belt LXS chain provides extra strength, increased wear resistance and wider application flexibility. This fabricated steel roller chain incorporates many advanced design and manufacturing refinements, resulting in superior ruggedness and accuracy.

Eliminate weak points

"Full-round" design does away with stress concentration points most frequently subject to failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly, increasing chain life.

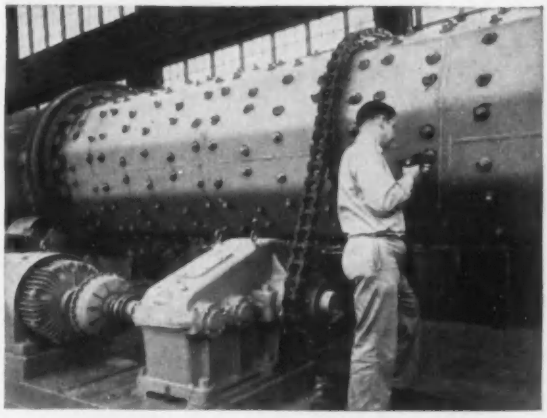
Pins and bushings are accurately sized for controlled press fit, preventing rotation in sidebars. Made from selected bar steel, sidebars are carefully machined for proper pitch hole size and for maintaining firm, tight press fit of pins and bushings. This assures close control of pitch and proper chain length after assembly.

Hardening extends life

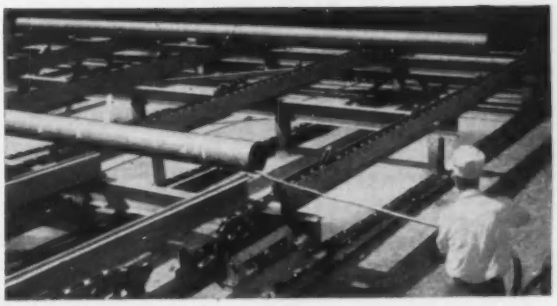
Another Link-Belt long-life extra is the controlled hardening of selected steels used in the manufacture of LXS chain. Pins, for example, are made from a tough steel, specially treated for high strength in shear and for maximum wear value. Bushings are properly hardened to shrug off shock and resist wear.

Rollers are accurately machined to assure proper operating clearances and free-rolling action. Controlled hardening gives them the necessary resiliency and durability.

LXS especially popular for exposed drives, high impacts



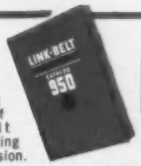
Link-Belt LXS chain is the long-life answer for exposed drives, abrasive and high-impact conditions. Its large, live bearing area reduces cutting action of abrasives because load is spread over a broad area.



LXS chain provides extra strength, wear-life for heavy-duty conveying

Link-Belt LXS chain has real stamina—as shown in this conveyor application for handling 1000-pound, 40-foot lengths of steel pipe. Thanks to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life for the extra-long conveyors so popular in today's move to mechanization.

For help with any chain problem call your nearby Link-Belt office. Send for 342-page catalog 950 covering the complete line of standard Link-Belt products for conveying and power transmission.



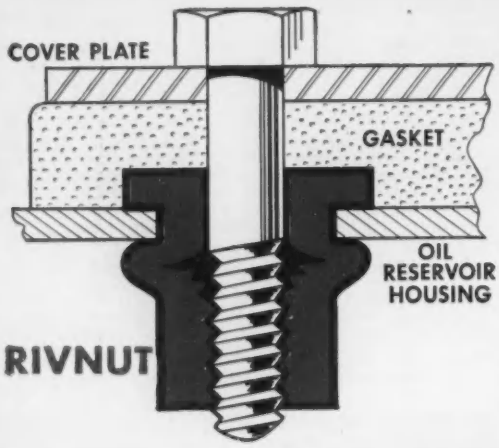
LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.258

B.F.Goodrich RIVNUTS

save time, cut costs by eliminating welding, tapping, cleaning



OLD WAY

1 Weld 4 nut plates to inside of housing
2 Drill
3 Tap
4 Clean
5 Attach cover with bolts

WITH RIVNUTS

1 Punch holes in housing
2 Insert Rivnuts and upset
3 Attach cover with bolts

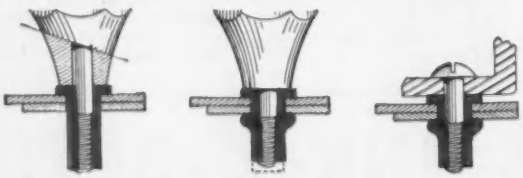
B. F. GOODRICH RIVNUTS cut costs and speed assembly by providing a firm, accurate nutplate in one operation!

This fastening job on Warner & Swasey's Multi-Purpose Gradall used to take five operations. Oil reservoir housings had to be detoured from the assembly line to weld four nutplates on the inside. Then they were drilled, tapped and cleaned before the cover could be attached. By switching to Rivnuts, welding, tapping and cleaning were eliminated.

Now one worker installs Rivnuts from one side in seconds. Assembly flow is straightline. Fastening time is cut in half.

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs and eliminated costly steps. They can do the same for you. Get more information or engineering help by writing: *Rivnut Sales, B. F. Goodrich Tire & Equipment Company, a Division of The B. F. Goodrich Company, Akron, Ohio.*

HOW RIVNUTS PROVIDE AT LEAST 6 CLEAN THREADS IN ONE SIMPLE OPERATION:



1 Rivnut is threaded onto pull-up stud of heading tool, then inserted.

2 Tool lever operates pull-up stud forming a bulge in the Rivnut shank.

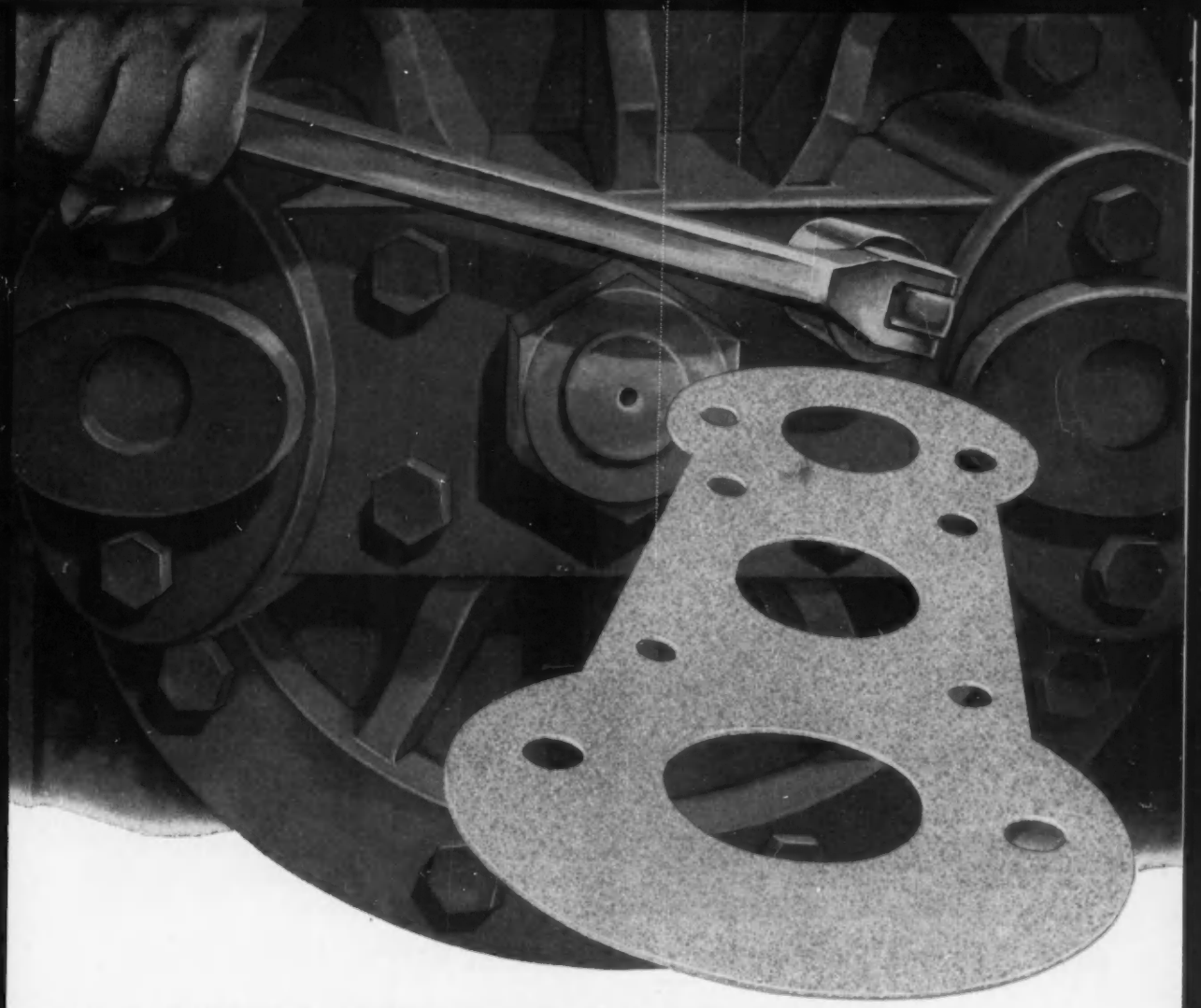
3 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

RIVNUT

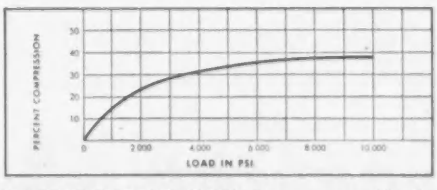
THE ONLY ONE-PIECE BLIND RIVET WITH THREADS

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy by writing to: The B. F. Goodrich Co., Dept. PE-116, Akron, Ohio.



New fiber gasket takes heavy loads with minimum bolt-torque loss



COMPRESSIBILITY. N-820, less compressible than other Accopac materials, is recommended for heavy-duty applications where flange pressures will be 2000 psi or more and temperatures do not exceed 250° F.

With Armstrong N-820 Accopac®, you can handle sealing jobs at high flange pressures even where temperatures at the gasket line go as high as 250° F.—conditions under which ordinary plant-fiber gaskets would permit serious loss of bolt-torque.

Field experience with N-820 Accopac shows that it has a maximum torque loss of 10-15%. This unusual performance often eliminates the need for re-torquing bolts in order to maintain the desired bolt pressure.

N-820 is made by a patented Armstrong process in which cellulose fibers are beater-saturated with a non-volatile latex binder. The result is a dense, crush-resistant material which has excellent torque-retention characteristics.

For more information on N-820 Accopac, write Armstrong Cork Company, 7011 Irvin Street, Lancaster, Pa.

Armstrong ACCOPAC

. . . used wherever performance count.

Carpenter... pioneering in improved Tool, Alloy and Stainless Steels through continuing research

TEMPERATURE: 110° F.
Permanent magnet assembly for watthour meter employing a magnetic shunt of Carpenter Temperature Compensator "30."
TEMPERATURE: -15° F.

When Precision Equipment Must Behave at Varying Temperatures... Take Advantage of *Carpenter* High Nickel Alloys!

A specially-engineered steel in Carpenter's complete line of high nickel alloys is guarding the accuracy of watthour meter performance in all kinds of weather. Its use covers a wide range of electrical equipment such as watthour meters, voltage regulators, speedometers and aircraft tachometers.

This alloy, Carpenter Temperature Compensator "30", is produced by specialists under strict quality controls. It is another example of how Carpenter's pioneering role in producing *specialty* steels to meet *special* applications works for you in your effort to build better products at a reasonable cost.

And Temperature Compensator "30" is but one of many Carpenter specialties. Other "extremely sensitive" alloys in this line respond to very weak electrical currents . . . permitting you to design smaller, lighter weight units. Still another Carpenter High Nickel Alloy assures precision product performance with practically no size change through temperature ranges up to 400°F.

Take this step for product improvement, now: Write on your company letterhead for detailed information on Carpenter Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys in such forms as strip, wire, bars, tubing and forging billets.

Carpenter STEEL

high nickel alloys

The Carpenter Steel Co., 117 W. Bern St., Reading, Pa.

Export Department: The Carpenter Steel Company, Port Washington, N. Y.—"CARSTEELCO"

Belt vibration is a design headache . . . eliminate it by specifying Veelos!

1 This test proves Veelos V-belts cut vibration up to 90%

Why chance running into vibration troubles when Veelos V-belts stop belt vibration before it starts. Particularly in designing for air conditioning, ventilating, refrigeration and precision equipment where belt vibration and noise are costly factors . . . *you owe it to yourself to see the Veelos Vibration Test* (above), before you specify. This test proves Veelos cuts vibration up to 90% over any belt you're using. The vibration story can become a big factor in selling your machines. With Veelos Belts you *assure* your customers of less bearing wear, less spoilage and less downtime.

2 Specify Veelos for a smoother-running drive

Ordinary V-belts have varying spots of density, due to their construction, which throw them out of balance. Veelos Belts are absolutely uniform; every stud and link identical; every foot of the reel is perfectly balanced. The beveled links, the machine-cut sides add up to better vibrationless performance. And by specifying Veelos, you're doing yourself a big favor . . . because your customers will be more pleased with the added efficiency of your machines. Your Veelos salesman can give you proof that Veelos outperforms any other V-belt, by test, right before your eyes.

3 Veelos allows you complete design freedom, too!

With Veelos you fit the belt to the drive, not the drive to the belt—because Veelos is adjustable to any length. You can use outboard bearings to advantage because Veelos is installed easily without dismantling any part of the machine. With Veelos you need not design for belt adjustment—no idler, no slide rail or any other belt-tightening device is needed. Simply add or delete links; that's all; no tilting or moving motors. A 15 minute demonstration shows you the many advantages Veelos offers.

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VEELOS
THE BALANCED
LINK V-BELT

Veelos is known as Veelink outside U.S.A.

For free vibration demonstration and Veelos Data Book write to:

MANHEIM

Manufacturing & Belting Company
207 Stiegel St., Manheim, Pa.

"Industrial Belt Specialists Since 1911"

New trends and developments in designing electrical products . . .

General Electric thermistors and Thyrite* varistors have unique properties that apparently contradict normal electrical laws. Here's how they can be harnessed to improve your product.

General Electric thermistors and Thyrite varistors are ceramic-like semiconductor resistance materials. Each has unique properties – apparently disobedient to normal physical laws – that enable it to perform tasks in electrical and electronic circuits which otherwise would require costly, complex components.

The distinguishing feature of thermistors is their *thermal* sensitivity. Thermistors have large *negative* temperature coefficients of resistance (i.e., their resistance decreases tremendously when heated, instead of increasing slightly like other materials).

Thyrite varistors, on the other hand, are *voltage*-sensitive. Contrary to Ohm's law, a current through a Thyrite varistor varies as a *power* of the applied voltage (i.e., doubling the voltage through a Thyrite varistor can increase the current from 15 to 25 times, instead of the normal 2 times).

The applications based on the unique properties of these materials are almost limitless. In general terms, thermistors are used in the detection, measurement, and control of minute energy changes; Thyrite varistors are used to protect, stabilize, and control circuits.

To give a clearer understanding of the ways thermistors and Thyrite varistors can be applied, here's how they have solved two of the electrical engineer's most vexing problems – temperature compensation and surge suppression.

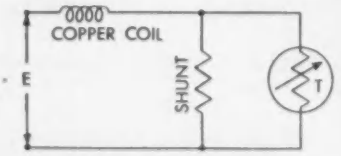


FIGURE 1 – Typical thermistor temperature-compensation circuit

The resistance of a conventional conductor is so affected by ambient temperatures that steady current flow cannot be maintained. For example, as the temperature of copper swings from −60° C to +80° C, the resistance increases 53%.

However, when the copper is compensated with a properly selected thermistor, the maximum deviation from the total average resistance at 25° C is only 3½% – despite the 140° swing in temperature.

In the circuit in Fig. 1, the thermistor's negative temperature coefficient of resistance offsets the positive temperature coefficient of the copper to stabilize current flow. In other circuits, thermistors can be utilized for signal and warning devices, sequence switching, and other time delay applications, because of the inherent thermal inertia involved.

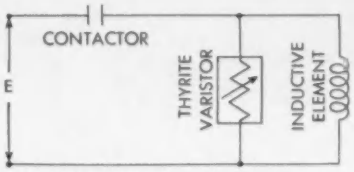


FIGURE 2 – Thyrite varistor surge voltage suppression circuit

Sudden interruptions of inductive circuits cause surge over-voltage, arcing, and high-frequency oscillations – all of which can cause trouble. The circuit in Figure 2 shows how a Thyrite varistor can be connected to hold these effects within safe limits.

With the Thyrite varistor out of the circuit, the surge voltage caused by interruptions of the current may rise to 9 times applied peak voltage (Oscillogram, Figure 3).

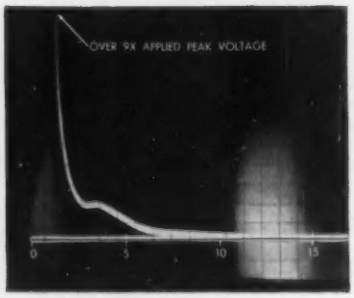


FIGURE 3

But with the Thyrite varistor in the circuit, (Figure 4), the surge voltage is limited to less than 3 times the normal applied peak voltage.

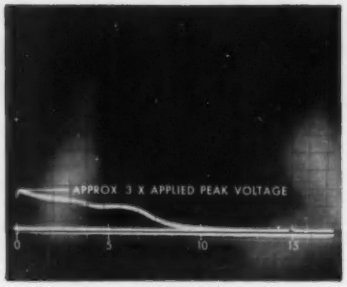


FIGURE 4

The Thyrite varistor draws negligible current at rated voltage, yet offers sufficiently low resistance at the peak current to limit the surge voltage to a safe value and to reduce arcing. Also, the Thyrite varistor quickly discharges circuit energy by providing increasingly higher resistance as the inductive current decays.

If a linear resistor were used to provide the same voltage suppression level, it would have to draw a current equal to more than 30% of the inductive element current.

In addition to surge suppression, a Thyrite varistor can be used as a nonlinear resistance parameter, a potentiometer, and a frequency multiplier. It can also be used as a bypass resistor to protect personnel and equipment from circuit faults.

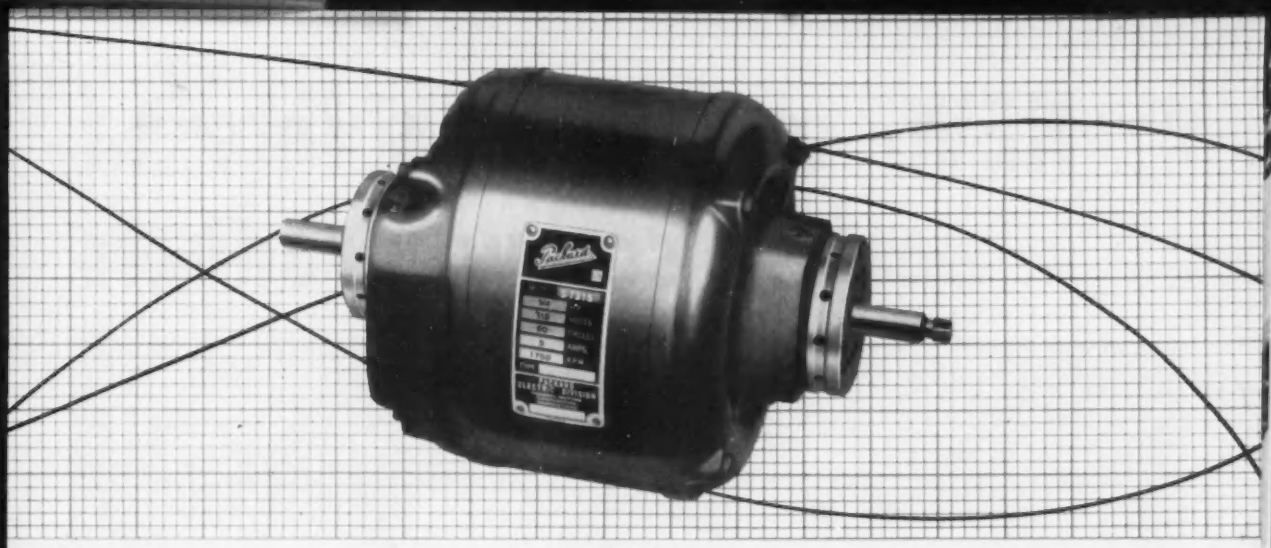
Technical literature giving complete data on properties, applications, sizes, and shapes of G-E thermistors and Thyrite varistors is available. And, for the experimenter, there are two engineering test kits on each.

To obtain kits, literature, or the assistance of a General Electric Engineer on your problem, write: *Metallurgical Products Department of General Electric Company, 11127 E. 8 Mile Road, Detroit 32, Michigan.*

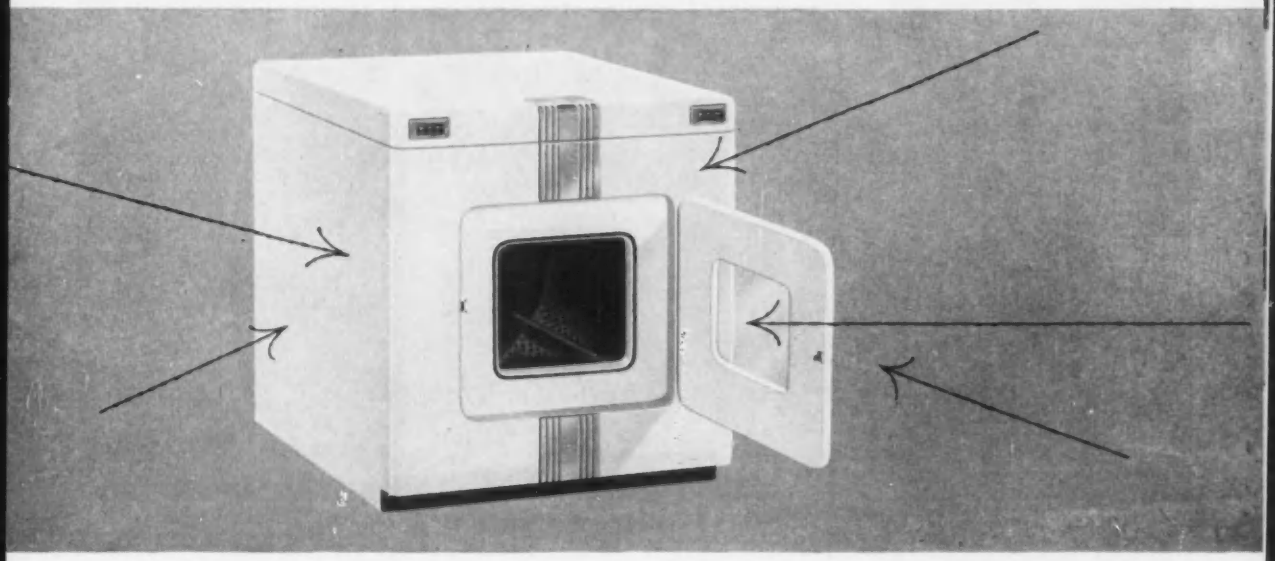
Progress Is Our Most Important Product

GENERAL ELECTRIC

*Registered trademark of General Electric Company



PACKARD ELECTRIC / *Because this motor was custom-tailored*



FHP MOTORS / *this dryer is built better at lower cost!*

Packard Electric direct factory sales and engineering contact consistently pays off. In this case it did for a dryer manufacturer.

The payoff came in a motor custom-tailored to dryer requirements . . . not merely a conveniently adapted motor. This means that the motor has the exact characteristics—speed, power and torque—for its job. Because of that, it could be advantageously priced.

What's more, it can be supplied with power supply cord already attached—complete and ready for installation. This results in still more savings.

Packard Electric research and engineering teams are busy today developing new motors. And as always, our objective is to enable customers to produce better, lower priced products in the future.

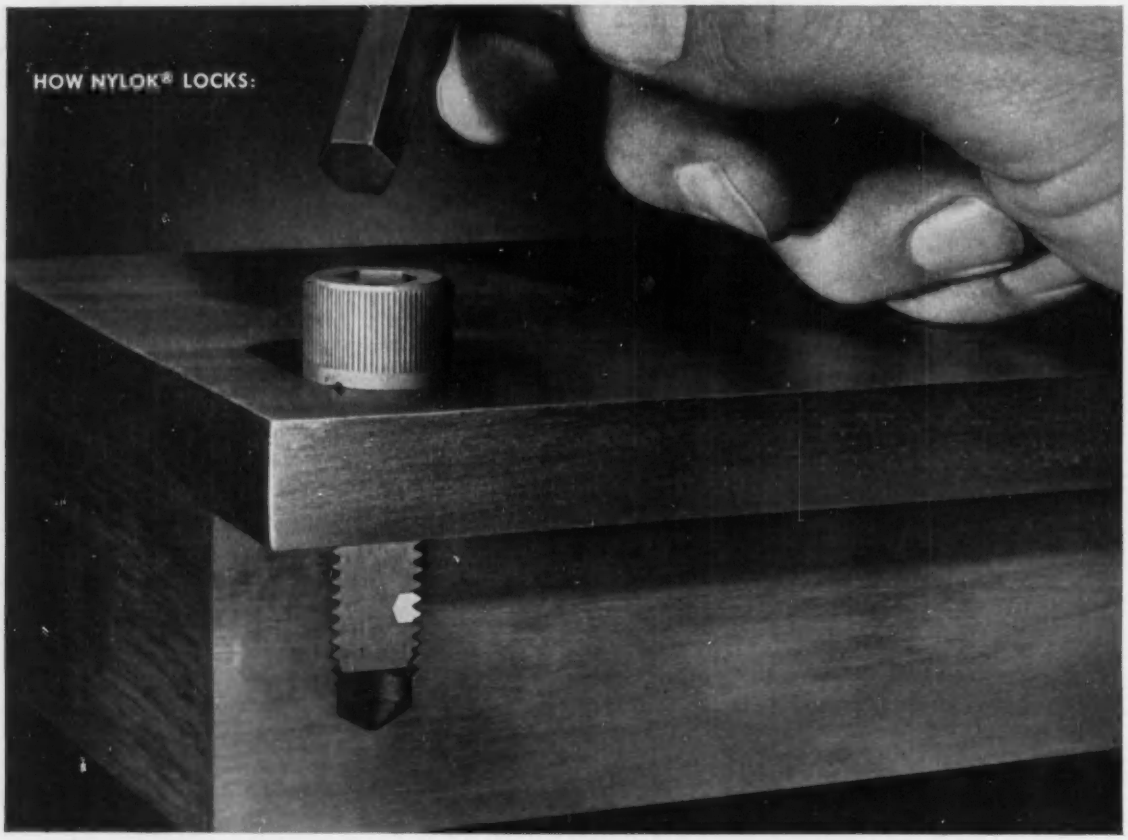
Packard *Electric*

Warren, Ohio

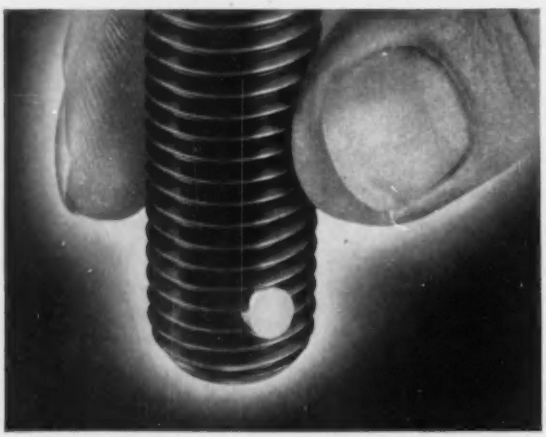
GM GENERAL MOTORS

Division of General Motors

NEW—a complete line of socket screw products



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together, and locks the screw securely.



BEFORE ASSEMBLY. The nylon pellet projects slightly beyond male threads. When assembled, female threads will be impressed into it. Pellet locks effectively whether the screw is seated or not.

AFTER REMOVAL. "Plastic memory" of pellet has expanded impressed threads to greater diameter than screw threads. Screw can be used repeatedly. In use, "memory" keeps threads tightly locked.

self-locking UNBRAKO that won't work loose

They simplify design and save production time

UNBRAKO socket screws are now available embodying the Nylok* self-locking principle. Nylok provides a truly practical new solution to the problem of making screws self-locking.

An UNBRAKO screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not shake loose.

You save production time when you build products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. So are cotter pins and complex multiple set screw installations.

Self-locking UNBRAKOS are completely reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, on properly seated screws, the pellet acts as a liquid seal.

Self-locking UNBRAKO socket screws come in a complete range of standard sizes and materials. See your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

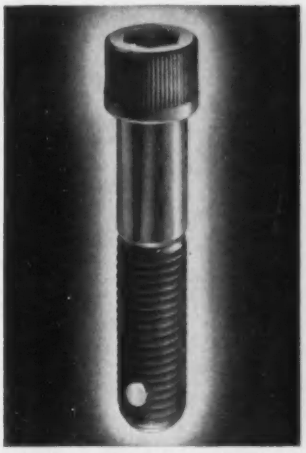
**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

UNBRAKO SOCKET SCREW DIVISION

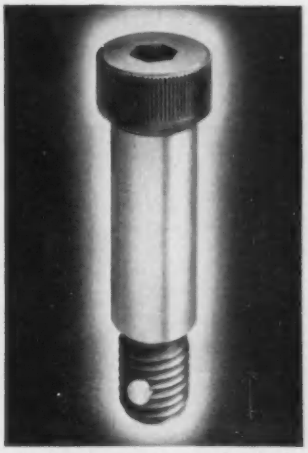
STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA



Socket head cap screws. Standard sizes #6 to 1 in.



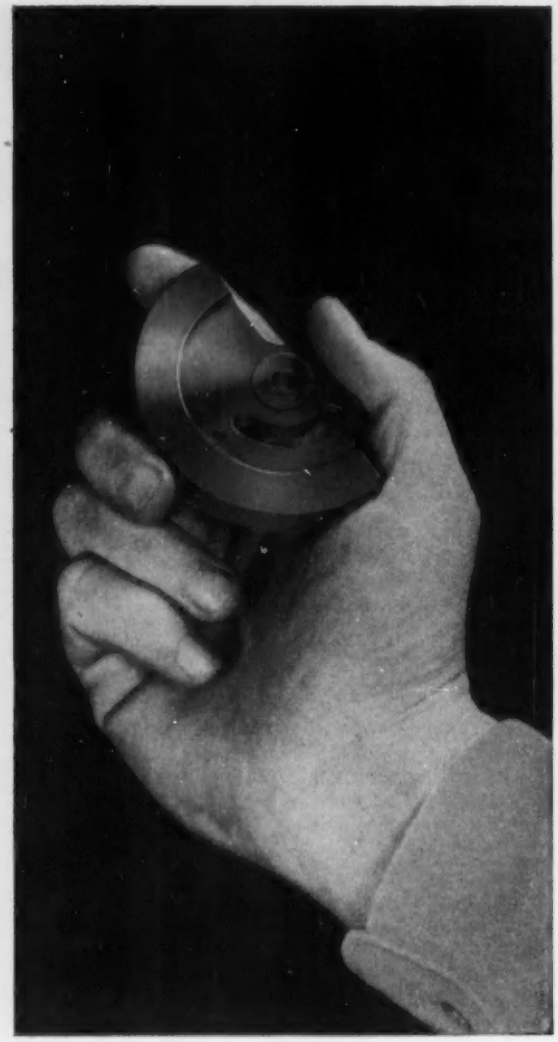
Socket shoulder screws. Standard sizes ¼ to ¾ in.

Socket pressure plugs. Standard sizes ⅛ to 1¼ in.

Socket set screws. All standard point types. Standard sizes #6 to 1 in.

Flat head socket screws. Standard sizes #6 to ¾ in.

Button head socket screws. Standard sizes #6 to ⅝ in.



which part should be made of metal powder?

We ask: **How will it be used in the end product of which it will be a component?** What are the loads, tolerances, and shape of the individual part? How will it be lubricated? Are there any special requirements such as hardness and finish? Do the quantities justify tooling costs?

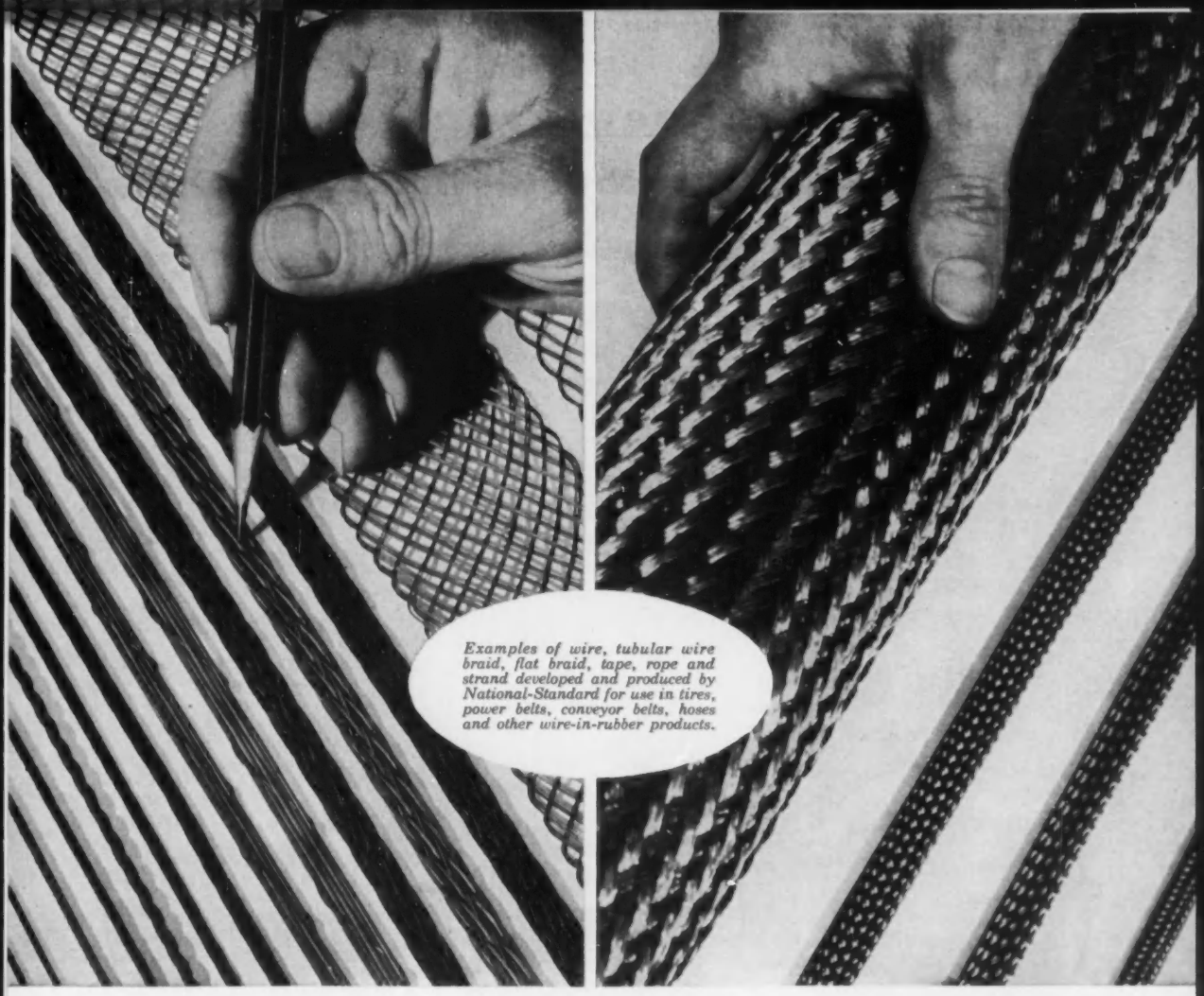
These are the questions that were answered before any decisions were made on the parts shown above —both of which are made of metal powder.

Because Moraine Products can draw upon a wide range of experience with many different mass production processes and their applications to specific problems, our judgment on these questions can be considered sound. When we recommend metal powder, it is because we are convinced, in our own minds, that it is the material and the process best suited for the job the specific part must do.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio



Examples of wire, tubular wire braid, flat braid, tape, rope and strand developed and produced by National-Standard for use in tires, power belts, conveyor belts, hoses and other wire-in-rubber products.

How product "X" might be improved

● Whatever you make, from cheese slicers to electronic brains, chances are wire of some kind in some form enters into your product make-up. Maybe it isn't special wire. Maybe it should be! In either case it is in this area that National-Standard service might help you produce a better product at lower cost.

For example, National-Standard has long devoted large scale research and engineering to improving the teamwork of wire and rubber—extensive work on wire fabrication, material, finish, corrosion, strength, elongation, adhesion and other factors that affect the behavior and cost of wire-in-rubber products.

You can draw on the fruits of all this and similar work performed for many other industries on the most effective use of wire.

So if you even suspect that a different or specially developed type of wire might improve your product or speed production, don't hesitate. Consult with National-Standard. We make a point of such service . . . want to be of help . . . and are geared to do it well, without obligation. Check with us now . . . or any time!

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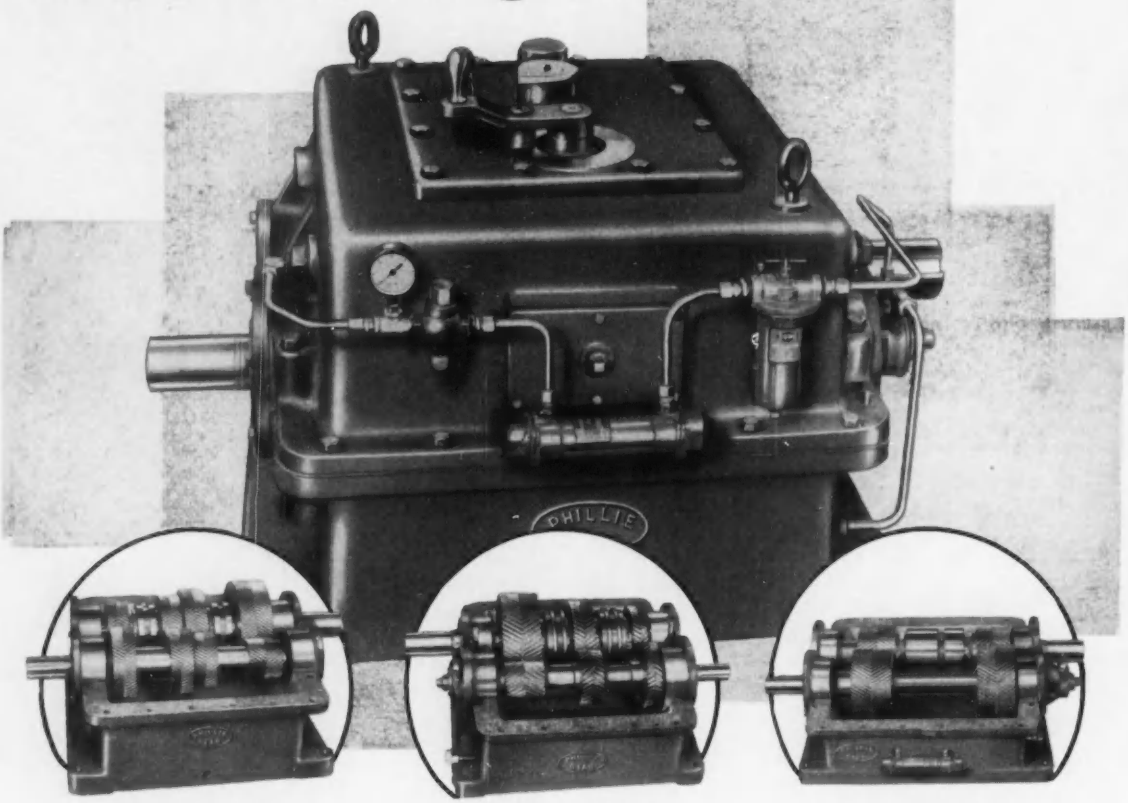

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Perspectives

IN DESIGN AND DEVELOPMENT

NUCLEAR FIELD IS EXPENSIVE

Businessmen in the atomic energy field got together in Chicago recently to compare notes. Certainly all were convinced that nuclear power will play a definite part in the future, but in living for the present, they have their problems, practically all of which involve money. For example, take the safety cost for reactor projects.

When the first three big reactors were designed for the Manhattan Project, every possible safety precaution was taken. Then they were built in the desert 15 miles apart. This isolation is estimated to have added $100-million to the cost of the first plutonium production. When the Materials Testing Reactor and the Nautilus prototype were built, the desert again was the locale. But as more was learned about them, the reactors moved closer to civilization. The safety cost, however, is still there, for all of the effects of radiation are not known. Consequently, the tendency is to design for the worst possible combination of circumstances, rather than the most probable. Design safety factors can snowball, and the cost is appreciable. Heat removal is a good example of this.

Take the design of a power plant which will produce 250 megawatts of electricity. To be sure of safe operation, many more lifetime tests at higher than normal operating conditions must be made to assure only that the initial investment will be protected. At this early stage, the costs for safety will be $250,000. The cost of the extra safety devices, trips, interlocks, and control instruments in the reactor will be about $250,000. The additional safety devices alone will increase operating cost.

With the plant located some distance from the optimum load center, the extra transmission lines could cost $1-million. An exclusion radius around the plant will be required. Such land costs will be about $2-million. Extra land cost could be another $1-million. Total safety costs add up to $4.5-million, or 9 percent of a $50-million plant.

In operating costs the penalty adds up to about 2 mils/kwh. If all other things would permit a total optimistic cost of 10 mils, then 20 per cent has been added to the operating cost.

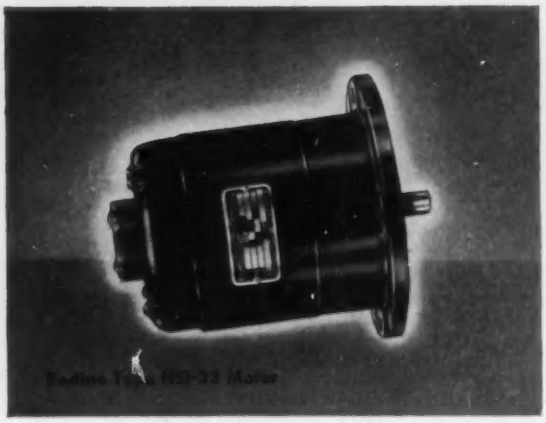
NO PROFIT IN PROCESSING FUEL

Low profit margins are responsible for the lack of interest in the field of chemical reprocessing of fuel. There are several reasons for this. One, is that a small reprocessing plant will cost about $15-million. Another is the lack of reactor facilities in operation which could give such a plant sufficient business. A third reason is the variety of complex shapes of the solid fuel elements in heterogeneous reactors. At present there is a need for standardization in the design of these fuel elements, and a reduction in the high degree of alloying. This will permit high put-through rates which would cut processing costs.

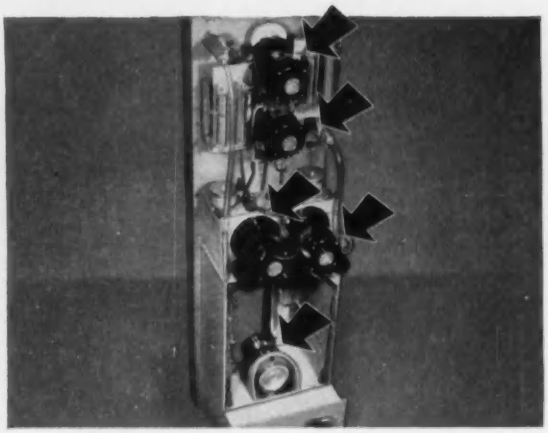
It has been estimated that the volume of wastes from processing spent fuel of the aqueous homogeneous reactors will be one-tenth that of the

(Continued on page 131)

Burroughs Datatron uses BODINE MOTORS because..."THEY REQUIRE MINIMUM MAINTENANCE, HAVE LONG LIFE"



This is one of the five Bodine Type N Motors used in Burroughs Datatron magnetic tape transport units which provide additional information storage for "electronic brains." Burroughs has found these motors to "have long life, require only minimum maintenance and be dependable." This and similar findings by other leading manufacturers are mainly the result of our close tolerance machining and attention to minor details often overlooked.



Here's an inside view of the Burroughs Datafile showing the five Bodine Motors. The top two 1/15 HP, 1725 rpm motors are shunt wound and drive the reels, while the middle two are 1/20 HP, 1800 rpm hysteresis synchronous units and drive the capstan. The lower split-phase motor is also 1/20 HP and powers the blower. The Bodine Motors are all part of the Datatron's vacuum column drive which gives stable strain-free tape movement with 6 ms start/stop time.

At the left are 3 Datatron magnetic tape transport units which are used to augment the computer's memory. Ten of these units can be used in a system, increasing the "electronic brain's" memory by more than 40 million digits. These magnetic tape units search, read and write data on their tape at 60 in/sec in either direction.

Mr. Duncan MacDonald is chief electromechanical engineer of ElectroData Division, Burroughs Corporation, Pasadena, California, manufacturers of ElectroData systems. Mr. Duncan tells how and why his organization selected Bodine Motors . . .

"The selection of Bodine Motors was no casual decision arbitrarily made. Dependability and reproducible performance were paramount requirements of the tape system. Naturally, the components used had to measure up to the design. Bodine Motors, we felt, met the requirements for dependability, minimum maintenance, and long life. The system's proven reliability in the field indicates our choice was the right one."

Be sure your motor is as good as your product. For information contact Bodine Electric Company, 2260 West Ohio St., Chicago 12, Ill.

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adding machines, letter openers, sanders, vending machines, exhaust fans, duplicating machines, hand dryers, portable tools, sound recorders, air conditioners, check protectors, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, calculating machines, envelope sealers, and for many other applications.

solid fuel elements of the heterogeneous reactors. This varies from 200 to 3000 gal of waste solution per lb of U^{235} consumed. The cost of storage of this material can amount to $1.50 per gallon

RADIATION EXPOSURE AND THE LAW

There is the case of the highway construction worker (call him Mac) who picked up a small, metallic object which he saw inside a section of large pipe. He put it in his pocket, not knowing it was a piece of Cobalt 60 which was being used to make a radiograph of the weld of the pipe. Mac left shortly afterwards, driving several of his co-workers home. The next morning when Mac returned to work, a geiger counter became aware of his presence, and the Cobalt-60.

Mac felt fine, but look at what could happen to him or his friends: (1) a cataract, leukemia, or cancer, maybe in the next 2 to 15 yr; (2) possible sterility, or production of offspring with genetic handicaps; (3) life span might be reduced; (4) psychological effect (loss of hair); (5) could be rejected for a job where radioactive work was being done although the exposure there might not be dangerous.

THE PROBLEM

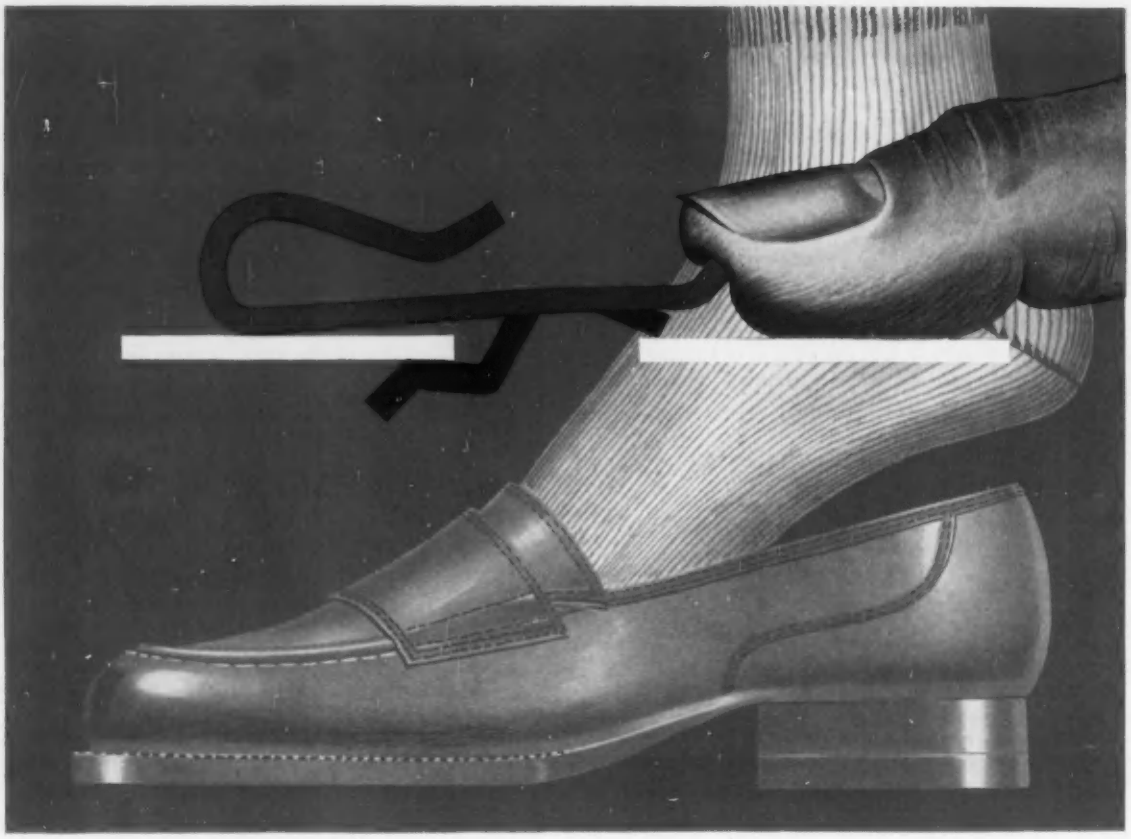
Whom would Mac sue, when, and for what?—his employer; the radiograph service; the manufacturer of the source? Is Mac liable to the passengers he drove home? How could he prove at a later date that whatever he contracted was caused by this exposure? What about the workman's compensation clause? There is a law which requires the person to notify the authorities of the accident within 30 days. What kind of medical pre-treatment and payment plan can be arranged?

Such are but a few of the legal questions which require answering. Also, power plant reactor operators are waiting for the government to come through with a bill which will underwrite the excess insurance in case of a catastrophic nuclear accident.

WANT TO GET INTO THE NUCLEAR FIELD?

The atomic energy field is attracting newcomers every day. The Atomic Energy Commission receives numerous inquiries each week ranging from, "How do I mine uranium?," to "I know just what I want to do. How do I get an access permit?"

As far as the Atomic Energy Commission is concerned, this is an easy field to enter. There are no patent licenses or royalty payments to worry about. For an interested manufacturer, the AEC will: (1) Acquaint him with the unclassified information available. Over 50 branch AEC libraries in the country have it. (2) Publish a list of people in the atomic energy field who will be prospective buyers for whatever the manufacturer might make. (3) Make AEC patents available to him. The Office of Technical Services has a list of patent abstracts for him to study. (4) Hold meetings on special classified subjects to which he is invited if he has an access permit. (5) Provide engineering drawings, classified or unclassified, for everything from pumps to reactors. He pays for printing only. (6) Prepare special bibliographies. (7) Will do a literature search for all material in any certain field. The manufacturer pays for this. (8) Have technical people available to discuss his problems.



MONEY-SAVING MAGIC IN THIS "HEEL AND TOE"

This Tinnerman fastener is modeled after your foot . . . there's a heel and toe . . . it slides easily into the holes punched in the metal, fiber, or plastic, even as your foot slides into a shoe. But it is much easier to put on than to take off!

The primary function of this SPEED NUT fastening principle is to provide a fast, easy-to-apply, low-cost, self-retaining fastener. Its snap-on attachment feature requires little skill and no welding or staking. Yet it assures positive retention for center panel or blind locations.

Tinnerman "heel-and-toe" fasteners can also have a wide variety of fastening features. The self-retaining heel-and-toe can be combined with the famous Tinnerman SPEED NUT impression. Or with a speedy cable clip . . . or a spring catch . . . a molding clip . . . a wire retainer . . . almost any fastening idea you require.

Tinnerman sales engineers are ready to make a SPEED NUT Analysis of your fastening requirements. Or you can write to us for details and engineering data. *Tinnerman Products, Inc., Box 6688, Dept. 12, Cleveland 1, Ohio.*

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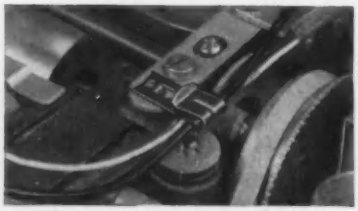
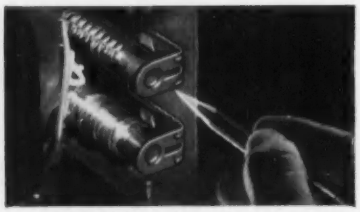
Speed Nuts®
FASTEST THING IN FASTENINGS®



On dictating equipment, this SPEED CLIP® holds wires safely away from moving parts.

SPEED CLIPS secure molding on plastic sign, help manufacturer gain 48% assembly saving.



Assembly of TV tuning coil to chassis and servicing simplified with special SPEED CLIP.

Corporations as Professionals

OVER THE PAST THIRTY YEARS OR MORE, various states passed laws requiring engineers to be licensed. To obtain a license the engineer must pass examinations and give evidence of a specified minimum of training and experience. Under the licensing laws, no man can legally practice as a consulting engineer without a license.

There usually must be a transition period after the enactment of such laws during which the profession gets oriented. One of the hardships threatened by the engineer-licensing laws was the possibility of making it extremely difficult for consulting-engineering corporations to operate. Many of them were headed by men who were primarily administrators. Of the administrators who were engineer-trained, many of them were too rusty to pass the required examinations.

A group of large design corporations is now active in trying to get the licensing laws modified to permit a corporation to offer consulting engineering services.

Obviously a corporation, which is an abstract entity, cannot meet the requirements for an engineering license. Nor can it design. That work must be done by individuals, human beings who have been specially trained.

Those opposing the proposed change in the engineering licensing law point out that a corporation per se cannot act as a professional engineer and they claim that the standing of a professional engineer will suffer and the intent of the licensing laws will be circumvented if the proposed changes are made.

This group of consulting engineering corporations criticizes the fact that the licensing laws are different in different states. That is a sound criticism. The licensing laws should be uniform for all states and of high standard. This is the trend.

The National Society of Professional Engineers is in the process of developing a so-called "ideal" registration law. It is hoped that this so-called "ideal" registration law will serve as an objective when the registration laws in the various states are up for revision. If that prevails, the "ideal" registration law will serve to provide greater uniformity in the licensing laws of the various states. And further, this "ideal" law proposes a means which might possibly solve the problems of the consulting engineering corporations with reference to licensing.

Issuing professional engineering licenses to corporations or changing the licensing law in order to permit a corporation to offer licensed consulting engineering services is a drastic step in the wrong direction. It would cheapen the value of and respect for engineering as a profession. The National Society of Professional Engineers is to be commended for its obvious interest in building and maintaining the professional standing of engineers.

George F. Rockwell

NEW DEPARTURE BALL BEARINGS CUT COSTS IN CONVEYOR SYSTEMS

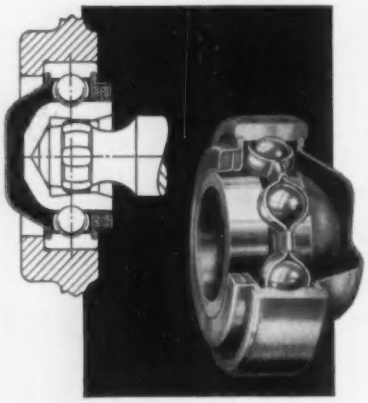
New Departure sealed and lubricated-for-life conveyor bearings have demonstrated their economy and dependability for many years in installations varying from sand and gravel plants to huge dam-construction projects.

These bearings do away with lubricating fittings, with grease piping, springs or adjusting devices and other miscellaneous items. Periodical greasing is eliminated with consequent important savings in labor and lubricant costs.

New Departure Type CB 504 bearings are unique in that they utilize short, easily removed stub shafts which allow a self-aligning motion in the bearing bore, yet at the same time prevent the inner ring from turning.

Carriers developed around these few parts are simple in design and remarkably easy to erect in the field.

For information on New Departure conveyor bearings, use the coupon below. Or call for New Departure's engineering service—ready to add its specialized experience to yours to help you build the best products possible. New Departure, Division of General Motors, Bristol, Connecticut.



Unique shape of the inner ring of Type CB 504, together with hexagonal curved surfaces on end of stub shaft, provides positive, self-aligning union between roll and supporting bracket.

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NEW DEPARTURE
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NOTHING ROLLS LIKE A BALL

Methods of Specifying Precision of SPUR GEARS

Analytical and functional methods of specifying gear size and tolerance, including: over-pins measurements; vernier gear-tooth measurements; block-gaging method; AGMA and modified AGMA methods; converting from one system to another.

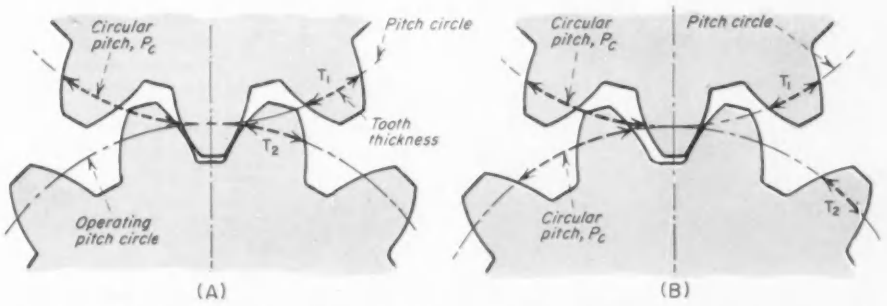


Fig. 1—Backlash is directly affected by tooth thickness as shown by gears without backlash in (A), and gears with backlash in (B). Backlash is equal to: $P_c-(T_1+T_2)$; therefore for gears without backlash, the circular pitch must be equal to: $P_c=T_1+T_2$.

G. W. MICHALEC
Section Head, General Precision Laboratory, Inc.
Academic Member of American Gear Mfgrs. Assoc.

SPECIFYING THE SIZE and precision of a gear has become a somewhat complex problem because of the many new inspection techniques recently evolved for measuring the size of a gear. The term "gear size" as used throughout the industry is in itself a cause for misunderstanding. The term developed out of its literal meaning of "size," as when defining a gear with a 3 in. pitch diameter, to the modern usage in which the gear size is specified by some indirect means, such as the tooth thickness or backlash with a certain tolerance. Indeed, in many of the present day inspection methods, the circular tooth thickness is the only important factor in specifying gear size.

Circular tooth thickness is the linear measure of tooth thickness along an arc at a specific radius from the center of the gear. The radius is usually to the pitch circle. Backlash is directly affected by the tooth thickness. In Fig. 1, two pairs of gear teeth are shown in mesh; one with backlash and the other without. Note that the backlash is equal to the difference between the operating circular pitch and the sum of tooth thicknesses on the pitch circles. Thus the tooth thickness is the important factor to specify in gear design, and to control in manufacture.

Methods for Specifying Gear Size

Methods of specifying gear size can be divided into two categories: **Analytical measurements** which are performed while the gear is stationary, such as the measure-

ment of tooth thickness, spacing, involute or helix lead; **functional measurements** which analyze the gear size while the gear is rotating in mesh with another, such as graphically recording the center-to-center distance or tooth-to-tooth action. Although both types have been in use for a long time, the functional method is becoming more popular because of its adaptability to mass production and automation. In addition, the functional method is more convenient to use with fine pitch gears.

Some of the analytical methods for measuring gear size are:

Over-Pins Measurements, shown in Fig. 2, require no special tooling other than a micrometer, and therefore are commonly used for the inspection of purchased gears—especially when quantities are not large. The tooth thickness at the pitch diameter is checked by placing two accurately ground pins of proper diameter at opposite positions and measuring over the pins with a micrometer. For inspection of gears with odd number of teeth, the pins are placed in tooth spaces as nearly opposite as possible. With narrower tooth thickness, the over-pin measurement is smaller.

Relationship between tooth thickness and over-pin distance is given by a series of tables in "The New American Machinists' Handbook," page 4-53, *McGraw-Hill Book Company*, New York. There are no standards for acceptable tolerance on over-pin dimensions; tolerance must be determined by the gear designer.

This method does not take into consideration the accuracy of the tooth profile. It assumes that the profile is an involute throughout the form of the tooth. In addition, the concentricity of the gear bore with the pitch circle is neglected.

To check both the concentricity and tooth thickness, the gear is held between centers, as shown in Fig. 3, and a pin is inserted between the gear teeth. A dial indicator checks each pin position, and the bore eccentricity is determined by the variations in the readings. Although this method is both cumbersome and lengthy it is still used to supplement some of the more modern procedures.

Vernier gear-tooth calipers as illustrated in Fig. 4, are often used to directly measure tooth thickness of gears. Teeth must be sufficiently large to permit insertion of calipers. The correct chordal addendum a_c and tooth thickness T, which must be known before inspection, can be obtained from pages 4-63 in "The New American Machinist's Handbook."

Since this method uses the top lands of the teeth as a

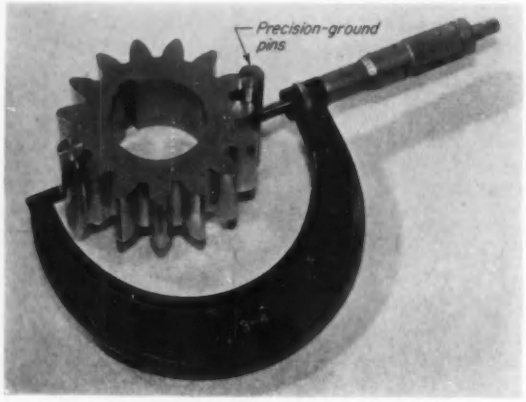


Fig. 2—Over-pins measurements require no special tooling for checking the gear size other than a micrometer and precision-ground pins. Measuring across pins indirectly measures tooth thickness at the pitch diameter.

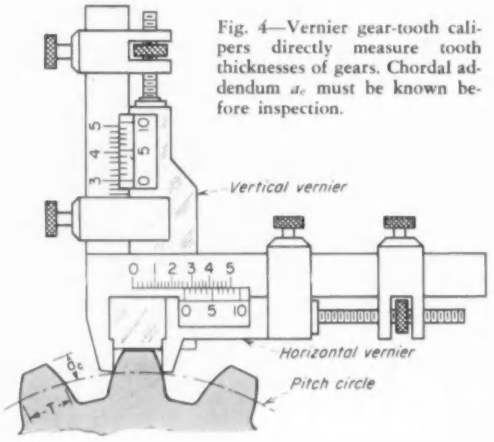
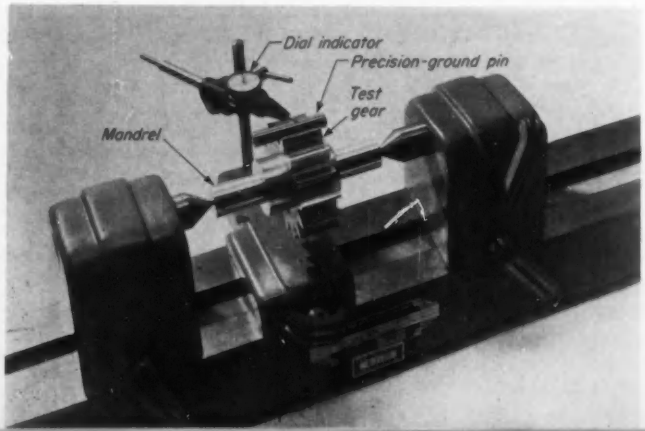


Fig. 4—Vernier gear-tooth calipers directly measure tooth thicknesses of gears. Chordal addendum a_c must be known before inspection.

Fig. 3—By using a fixture with a dial indicator, each tooth space can be checked for concentricity with respect to center of bore. Test gear, mounted on a snug-fit mandrel and held between centers, is rotated for tooth-by-tooth measurements.



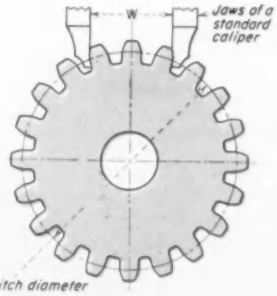


Fig. 5—Standard vernier caliper can be used to measure chordal length W of two or more teeth and then compared with calculated values. Specifying the pitch diameter with a desired tolerance is not desirable since it cannot be directly measured.

reference, any error in the runout of the outside diameter is reflected in the measurements. Also, the physical dimensions of a caliper restrict this method to gears with a minimum pitch of 24P.

Block-gaging method, Fig. 5, uses a standard caliper whose jaws contact the pitch circle over two or more teeth and the chordal dimension W is compared with calculated values. Pitch diameter is often specified on the drawing of a gear with the desired tolerance. The inferred control is that the cutter used in generating the gear should penetrate into the blank the exact nominal amount to result in perfect tooth thickness, with a depth tolerance equal to one half the pitch diameter tolerance. Thus, this specifiation resembles the technique used in master rack and gear rolling since the hob, or other generating tools, can be assumed equivalent to the master rack or gear.

Theoretical objection to this procedure is that a gear does not have a pitch diameter until meshed with a rack or gear. Also, once meshed with its mate, the pitch diameter is exact and is not subject to any tolerance.

Practical objection to specifying gear size by pitch diameter is that it cannot be directly measured and the data must be converted for use with another measuring method, such as over-pins or variable center distance measurements. Thus this method is neither analytical or functional since some other method, which can be either, is inferred.

Because of these objections, the method of specifying the pitch diameter should be discouraged. Fortunately, the popularity of this one-time dominant procedure is decreasing because of the growing development and acceptance of other improved methods.

Functional Inspection Methods

Most popular functional method for determining gear size is the use of a variable-distance rolling fixture employing a master spur gear, worm section, or rack. Gear to be measured is meshed tightly under pressure with the master and rotated, thus functioning as in actual practice. The master gear is usually hardened and ground, and by previous inspection known to be highly accurate with respect to runout, pitch error, accumulated error, profile error and lead-angle error.

As the gears are rotated, the center-to-center distance between gears will vary from tooth to tooth. Variations are observed with a dial indicator and since the thickness of the master gear teeth is known to be a constant, variations in the center-to-center distance are attributed to variations in the tooth thickness of the inspected gear. Formulas relating the variations in the center distance to the change in tooth thickness involve complicated involute functions. However, the following approximate formula is of sufficient accuracy for most cases:

$$B = 2\ (\Delta C.D.)\ (\tan \phi) \qquad (1)$$

where:

B = backlash or equivalent change in tooth thickness
$\Delta C.D.$ = change in center distance
ϕ = pressure angle

Thus, the desired tolerance on tooth thickness can be converted to an allowable center distance range by Eq. (1). This range should be specified on a gear drawing to give specific instructions to the inspection department.

Advantage of the rolling method is that, simultaneously with the indirect measurement of tooth thickness, any eccentricity between the gear bore (or centers if of the boreless type) and the pitch circle will be revealed. Bore eccentricity, which results in pitch circle runout, will be noted as a cyclic variation of the center distance with gear rotation. In addition, the tooth action can be observed and any tooth-to-tooth errors will appear as a variation of the center distance.

Total variation in the center distance is called the Total Composite Error, or TCE; Fig. 6 shows a typical plot of a gear with runout and tooth-to-tooth errors. Similar plots can be obtained directly from the graph recorder of a variable center distance testing machine, such as shown in (A) of Fig. 7, or from accumulated observations using a dial indicator, as shown in (B).

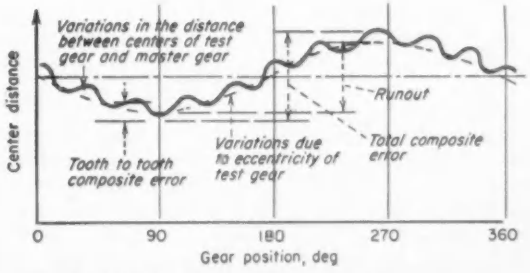
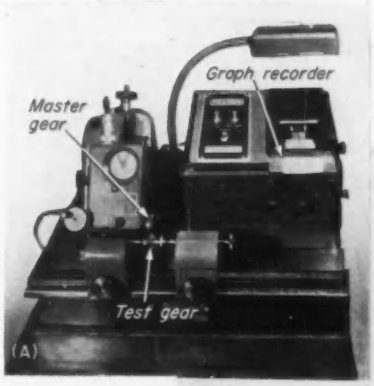


Fig. 6—Variations in the distance between the center of a test gear and the center of a master gear as the gears are rotated in mesh. Variations are caused by inaccuracies in the teeth of the test gear, as indicated by the small pulsations, and by the eccentricity of the bore, as indicated by the dashed line.



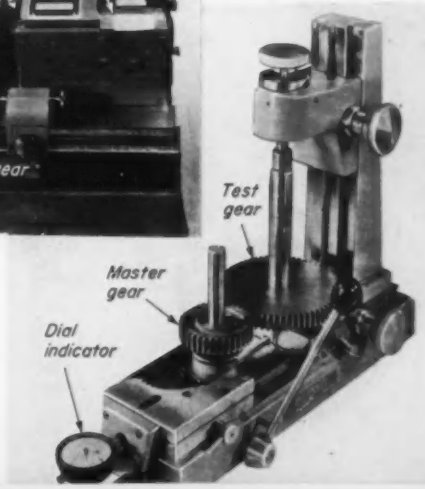


Fig. 7—Center-to-center distances of a test gear in mesh with a master gear can be obtained directly by (A) testing machine with a graph recorder *(Fellows Gear Shaper Co.)*, or by (B) accumulated observations from a testing machine using a dial indicator *(Illinois Tool Works)*.

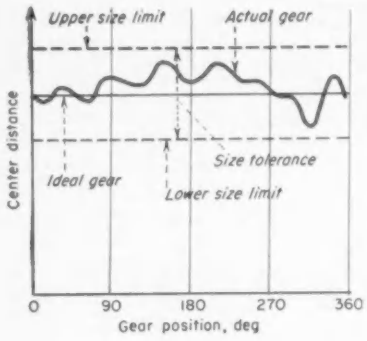


Fig. 8—Although the ideal gear with no total composite error will have a straight line curve somewhere between the upper and lower size limits, in actual practice the curve will appear as show by the line in color.

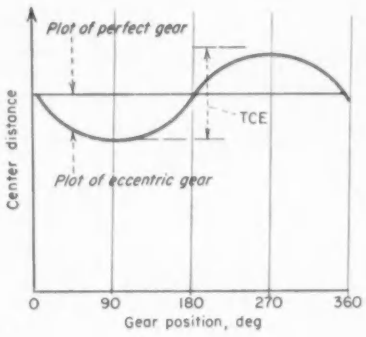


Fig. 9—Comparison of center distance curves between a perfect gear and a gear with an eccentric bore. Total composite error is caused only by the eccentricity.

Interpretation of Inspection Data

One of the biggest difficulties in applying the variable center distance procedure is the correct interpretation of the inspection data because of the simultaneous presentation of size, runout and tooth-to-tooth variations. An ideal gear, having TCE of zero would have a straight line curve, as shown in Fig. 8, which may fall any place between the upper and lower limits of the permissible size tolerance. In actual practice, however, the gear will contain some total composite error and the center distance curve will appear as shown by the line in color. To determine the size from such a curve is not as simple as for the ideal case because the center distance varies with rotation. If the variation was sinusoidal, caused solely by an eccentric gear center, the average value would be an accurate indication of true gear size. However, the presence of tooth-to-tooth variations, plus the deviation from a true sinusoidal runout component, creates uncertainty in assuming the average of high and low readings to represent exact size.

Critical criterion for a gear in operation is that there is no binding. Thus, the highest indicator reading, corresponding to maximum center distance, is the item to closely control. This results in one method of specification, the method of the American Gear Manufacturers' Association (AGMA), which calls for the value of highest indicator reading and a tolerance for it. But this is not an indication of gear size.

The TCE is independent of gear size. As an illustration, assume the existence of a boreless perfect gear of exact tooth thickness. If meshed with a master, the gear would yield a graph shown by the black line in Fig. 9. Now assume a diameter is bored into the gear. If the bore center is not exactly on the theoretical gear center, the total composite error of the gear, when measured by rolling, will be as shown by the line in color. The value of TCE will depend upon the eccentricity of the bore. Tooth thickness of the two gears are identical; but because of TCE error the eccentric gear will have a larger maximum indicator reading. Also, it can be seen that the average center distance value is the best figure to use for determining tooth thickness, especially when comparative measurements are to be made with other gear size measuring techniques.

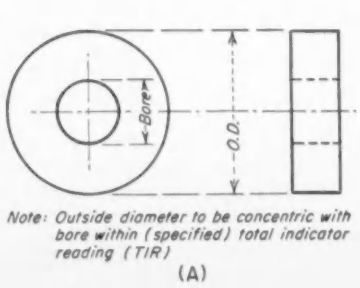
Why Gear Size is Independent of TCE

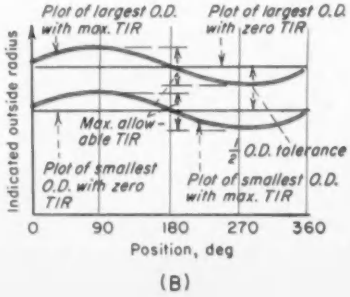
Identical limits should not be arbitrarily established for size and TCE because of the independent nature of these two parameters. Gear size is determined by the setting of the gear generating tool, such as the depth of cut of the tool. However, TCE is the result of a number of independent items unrelated to the cutting depth of the teeth, such as: runout of the work arbor, tool arbor, gear hob or cutter; clearance between the gear blank, tool bores and the mounting arbors; and general condition of the tool. Thus, any one or several of the above items can cause TCE, although each is independent of gear size.

The converse is also true. Gear size, as determined by depth of penetration of the cutter, does not affect TCE. For example, a fixed amount of runout on the work arbor of a gear generator will result in a specific component of TCE regardless of any specific gear size.

In addition, backlash does not affect conjugate gear action (constant velocity ratio), whereas TCE causes a cyclic positional error. Actually, backlash in gears does not affect position except when the gears are reversed. Although backlash has the appearance of positional error in a frequently reversing drive, there is no positional variation in uni-directional drives. Finally, many gear trains are designed with anti-backlash gears or adjustable centers. For such designs the tooth thickness is of secondary impor-

Fig. 10—Disk with a concentricity specification as shown in (A), is permitted by the specification to have variations in the outside radius as shown in (B).





tance, whereas the TCE control may be very significant.

Independence of TCE and gear size can be further illustrated by the following analogy. Consider a disk, machined on a lathe, with a smooth outside diameter (O. D.) and a bore, such as shown in (A) of Fig. 10. The O. D. is a critical dimension and has a specified concentricity with the bore–also a critical parameter. For such an item, it is common practice to specify the O. D. with a tolerance and add a note calling for a specified TIR (Total Indicator Reading) between the O. D. and bore diameter.

Possible variations in the outside surface of the disk are shown in (B). Included are curves of the largest and smallest permissible outer diameters, based on the maximum TIR. It can be noted that the O. D. and concentricity (run out) are independent of each other and that the O. D. dimension is analogous to gear size while the O. D. circumference runout is analogous to TCE. In addition, the disk can have its size and run-out specified in terms of an outside radius by giving a range of the mean of the plot and a maximum TIR value in terms of the difference between maximum and minimum radius.

Although the curves for a gear would not be as smooth as for the disk, and would show tooth-to-tooth variations, an identical procedure can be applied to size and TCE control of gears. In other words, the mean value of the curves of the center distance graph can be specified to fall within a range of values with a specified value for the maximum TCE.

AGMA System of Specifying Gear Size

An increasingly popular system for specifying gear size is the AGMA procedure as specified in Standard No. 236.04. The system is based upon the variable center distance technique discussed above. Gear size is specified in terms of backlash that a pair of gears would have if meshed on perfect standard centers (theoretical or nominal). Four categories of precision have been established, as shown in Table I.

Backlash values are understood to be backlash between two assembled gears at their tightest point of mesh. Backlash will be increased when the low points of runout are in contact. The classes of blacklash refer to gear size only, that is, the tooth size necessary to achieve the specified backlash when meshed on theoretical perfect centers. This does not establish the final net amount of backlash in an installation, but only affects it as one source. Total backlash is an integration of many sources, such as center distance tolerance, bearing runout and bearing clearances.

In the AGMA standard, backlash is specified as a total value per pair of mated gears, assuming they are mounted on ideal nominal (standard) spaced centers. Since the permissible amount of backlash depends upon the application, it is not specified and therefore must be determined by the gear designer. For example, pinions that have been undercut cannot be further reduced; therefore, in such cases, the mating gear should be cut with all, rather than half the desired backlash. On the other hand, if two pinions or two gears are mated, the backlash should be divided equally between them. The AGMA standard intentionally provides flexibility since it is applicable to the entire gear field. However, for most applications, it is practical to standardize upon dividing the backlash equally between mated gears.

Backlash data of Table I can be further developed into specified minimum backlash and a value of tolerance. This extrapolation from Table I is done in Columns 1 and 3 of Table II. The intentional backlash is the minimum that is necessary for accommodating manufacturing variations such as bearing and mounting eccentricities and housing bore tolerances, which could combine in the installation of the gears to cause interference. Because the variable center distance procedure is implied by this standard, the data are further expanded into equivalent center distances in Columns 2 and 4.

Since the most important design criteria is that there is no binding of meshed gears, the backlash specification applies for the tightest point of mesh between pairs of gears. Fig. 11 analyzes this concept with a graph. Note that only the highest point of the center distance plot is controlled; however, to maintain control of the minimum value, a total composite error must also be specified. Thus, the high point of indication must come within the specified tolerance limits, and the low point cannot differ from the high point by more than the maximum allowable total composite error.

A further important feature of the AGMA standard is that it recognizes that the gear size and TCE should be separately specified. Table III lists the various AGMA classes for TCE. Procedure for specifying a gear is to desig-

Table I—Permissible Backlash per Meshed Pair
(From AGMA Standard 236.04)

	Diametral Pitch	Backlash, in.
Class A	20 to 45	0.004 to 0.006
	46 to 70	0.003 to 0.005
	71 to 90	0.002 to 0.0035
Class B	20 to 60	0.002 to 0.004
	61 to 120	0.0015 to 0.003
	121 and finer	0.001 to 0.002
Class C	20 to 60	0.001 to 0.002
	61 to 120	0.0007 to 0.0015
	121 and finer	0.0005 to 0.001
Class D	No measurable backlash at any pitch	

Table II—Conversion of Backlash Figures of Table I into Components of Intentional Backlash and Backlash Tolerance

Diametral Pitch	Intentional Backlash, in.		Backlash Tolerance, in.	
	(1) Per Pair	(2) Equivalent Center Distance	(3) Per Pair	(4) Equivalent Center Distance
Class A				
20 to 45	0.004	0.0055	0.002	0.0028
46 to 70	0.003	0.0041	0.002	0.0028
71 to 90	0.002	0.0028	0.0015	0.0021
Class B				
20 to 60	0.002	0.0028	0.002	0.0028
61 to 120	0.0015	0.0021	0.0015	0.0021
121 and finer	0.001	0.0014	0.001	0.0014
Class C				
20 to 60	0.001	0.0014	0.001	0.0014
61 to 120	0.0007	0.0010	0.0008	0.0011
121 and finer	0.0005	0.0007	0.0005	0.0007

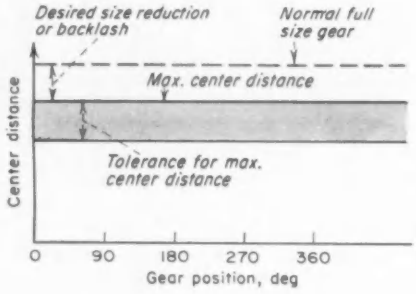


Fig. 11—To avoid any possibility of binding between two gears, the AGMA standard controls gear size by requiring that the maximum center distance should fall below the nominal value, with an amount equal to the desired backlash.

Table III—AGMA Standard for Total and Tooth-to-Tooth Composite Errors

(From "AGMA Standard 236.04" for fine pitch gears; applicable to spur, helical, worm and bevel gearing)

Class		Total Composite Error, in.	Tooth-to-Tooth Composite Error, in.
Commercial	1	0.006	0.002
	2	0.004	0.0015
	3	0.002	0.001
	4	0.0015	0.0007
Precision	1	0.001	0.0004
	2	0.0005	0.0003
	3	0.00025	0.0002

nate a TCE class along with a backlash class. The combinations can be made in any reasonable manner. Thus, gears can be designed as: Precision 1-B, 1-A, 2-C; Commercial 3-A, 4-B.

Examples of AGMA Specifications

Consider a pair of identical gears with a 48 diametral pitch, 20 deg pressure angle, 96 teeth, and AGMA Class Precision 1-A. One half of the specified intentional backlash per pair is to be cut into each gear and the pair is to have equal size tolerances.

From Tables I and III, the class of the gears allows a maximum total composite error of 0.001 with a backlash of 0.003 to 0.0005 per pair at the tightest point of mesh (all dimensions are in inches). Since the gears are to have their teeth reduced equally with the same size tolerance, the backlash per gear is 0.0015 to 0.0025. Referring to Table II the equivalent change in center distance will be 0.0041 to 0.0069 per pair, or 0.002 to 0.0034 per gear.

Size limitations of the example are shown in (A) of Fig. 12. For a gear to be acceptable, its tightest point of mesh with the master gear must fall within −0.002 and −0.0034. However, the TCE requirement of 0.001 must be met regardless of where the tightest point of mesh falls within the specified limits. Thus, the center distance curve can fall below the −0.0034 value as much as 0.001, provided the tightest point or high point falls at −0.0034. This would be the plot of the smallest acceptable gear with limits as shown in (B).

The term "nominal" refers to the distance between centers of a theoretically perfect master gear mating with a theoretically full tooth thickness gear. With tooth thinning, the center distance will fall below nominal as shown by the negative numbers. The term "center distance" is loosely used since it would not be correct terminology if a master rack is used instead of a gear.

Largest acceptable gear would be one without any TCE. This coincides with the upper limit line. Thus, the true range of size in terms of center distance can vary from −0.002 to −0.0044, providing that at least one tooth falls at or above −0.0034. Or in terms of tooth thickness, it would be equal to the equivalent range at tightest point of mesh plus half the TCE tolerance.

Other values of TCE within the allowable range may be chosen; Fig. 12 (C) shows the extreme size range for a value of 0.0003 TCE. Regardless of the TCE value, the size tolerance (spread) remains constant.

Pertinent data to be specified on a gear drawing are listed in Table IV. In actual practice the type and size of the inspection master is known; therefore, the numerical nominal center distance can be readily calculated. This allows the direct insertion of numerical limits on the gear drawing. Some designers specify the ordinate of the plots as "gear pitch radius" in the gear data tables on drawings.

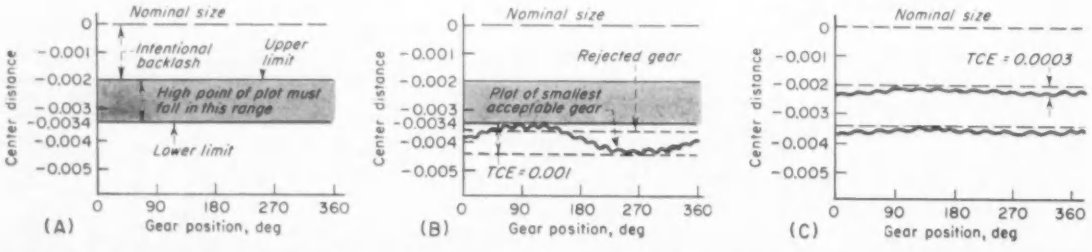


Fig. 12—(A) Size limitations of a spur gear with AGMA Precision 1-A tolerance requirement. Center-to-center distance must be undersized from 0.002 in. to 0.0034 in. to give an intentional backlash to gears when mounted at a nominal center distance. (B) A minimum of one tooth falling in the 0.002 to 0.0034 range is sufficient to make the gear acceptable, providing that the total composite error (TCE) is not more than 0.001 in. This is illustrated by the plot of the smallest acceptable gear. Largest acceptable gear is the straight line in the upper limit. (C) Acceptable plot if the TCE is reduced to 0.0003 in.

Although convenient to use, this concept is not technically correct because the plots do not truly represent the gear pitch radius. Validity of this objection can be established by considering the mesh of a master gear and test gear of identical design. For such a one-to-one ratio, the pitch radii are altered exactly by one half the magnitude of the changes in center distance.

Table IV—Specification for a Typical Gear Using the AGMA System

Pitch	48
Pressure Angle	20 deg
No. of Teeth	96
Nominal Pitch Dia	2.0000 in.
AGMA Class ..... Precision	1-A
Max. Total Composite Error	0.001 in.
High Point of Center Distance reading to be within	(Nom. C. D.–0.002) to (Nom. C. D.–0.0034)*

*If details of the inspection master are known specific numerical values can be calculated and specified.

Limitations in the AGMA System

At first, it may not seem practical that the AGMA standard is based on the highest value of center distance plot. Perhaps one would expect a control based upon the range of the mean value of the center distance plot and a maximum TCE value such as was developed in the disk analogy of Fig. 10. However, there are important objections to such a specification: First, the average or center line of the plot must be interpreted since it is not directly obtained. This would create confusion in the shop. Second, the maximum value of the tightest point of mesh is a critical criteria, but is at a very desirable end of the size tolerance range, since it results in a minimum backlash condition. Thus, it would be desirable to accept gears with TCE approaching zero and size equivalent to the maximum value of the high point.

Therefore, any straight line plot between the limits of −0.002 to −0.0025 is acceptable and indeed very desirable. On the other hand, if the definition was that the −0.0025 line represents the maximum mean value of the plot, gears with approximately straight line plots between −0.002 and −0.0025 would not be acceptable. This would sacrifice both material and quality.

However, the AGMA standard rejects some gears which are better than acceptable ones. Referring again to the previous gear example in Fig. 12(B), the AGMA standard rejects any gear whose plot fails to reach the minimum center distance value of −0.0034 at any point, such as the plot of the rejected gear. The paradox is that in actual practice these rejected gears have a lower average backlash than the minimum acceptable gear. The rejection of these gears may be a handicap if close tolerances are required. This fault could be obviated by specifying the minimum size in terms of the mean value of the plot. However, this method has objections already mentioned. Also, to use different definitions for the minimum and maximum limits of the center distance plots could lead to endless confusion in the shop.

Need for correcting this fault in the AGMA specification is not paramount because the fault only affects gears on the extreme small end of the tolerance range. Presumably, most gears will be distributed within the mid-area of the tolerance range, with only a few falling into this questionable area.

Modified Standards

Modified methods of specifying gear size, based on the original AGMA standards, have appeared recently in the industry. Some of the modifications attempt to eliminate the paradox of rejecting gears in the low tolerance range while accepting others with poorer qualities. Other modifications attempt to pave the way for easier inspection procedures in the shop. Since the goal is to have a universally accepted system, preferably the AGMA's, the four major offspring systems, which are reviewed below, should be analyzed and understood.

System with identical Size and TCE tolerance: Probably through misinterpretations, a system has been developed which establishes identical ranges for size variation and TCE on the center distance plot. The AGMA classes for TCE and backlash are used, although the latter is modified, and the AGMA call-out designation is employed. The backlash table is modified in that only the intentional backlash value is used. This establishes the maximum center distance dimension. Minimum limit is established by the maximum TCE as shown in Fig. 13(A) using the previous gear example as an illustration.

Main objection to this system is the interdependence of size and TCE. For example, as a gear increases its TCE to the maximum limit, the size tolerance diminishes and becomes zero. Similarly, as the size variation increases, the balance of the tolerance for TCE diminishes. Although this would control the size of gears more closely and therefore result in more precise gears, it is an extreme hard-

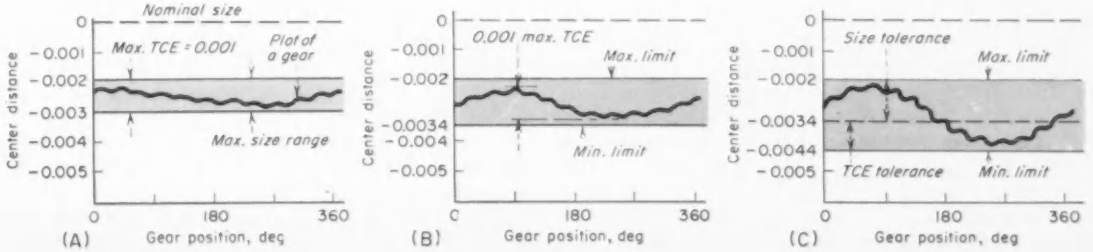


Fig. 13—Modified AGMA systems: Curves must fall within shaded areas: (A) System with TCE and Size range. (B) System with specification that the TCE tolerance must be smaller than the size tolerance. (C) System with positive high-low limits. TCE tolerance is added to size tolerance; plot must fall within the sum tolerance.

ship to the manufacturer. In addition, the inflexibility of this system would not provide means for designing highly accurate (low TCE) gears with wide size tolerance which is often desired when anti-backlash techniques are included in the gear installation.

Admittedly, one value of the modified system is that gear inspectors can merely check to see that the entire gear plot falls between the two specified limits. This is simpler than the true AGMA system where the value of the high point must be checked along with the range of TCE.

In general, this modified system should be discouraged, not because the gears passing inspection would be too precise, but because in many applications the precision is unnecessary. It should be remembered that the AGMA specification is sufficiently flexible to allow for the design of equally precise gears.

System with entire TCE variations within size tolerance: This system is a more rational modification of the original AGMA specification because it allows the full center distance range to encompass all TCE fluctuations, as illustrated in Fig. 13(B). This procedure still allows for independent specification of size and tolerance, but specifies that the size tolerance shall always be larger than the TCE tolerance.

Primary object of this modification is to simplify inspection by eliminating the fluctuating minimum limit, which is a function of TCE, as defined in the AGMA standard. In this system the bottom limit is fixed, but the inspector must still independently check that the TCE is within specified tolerance.

To specify a larger size tolerance than the TCE tolerance is logical because in many applications the TCE tolerance is more critical. However, this may not apply for highly precise gears. Also, because this system eliminates the fluctuating lower limit, the backlash classes become tighter.

System with positive high-low limits: Another variation of the AGMA standard is to establish the maximum and minimum center distance values as the sum of the equivalent backlash tolerance and the allowable maximum TCE. Then the requirement for acceptable gears is to simply have the entire plot fall within these limits plus maintaining a plot spread of no more than the allowable maximum TCE, as illustrated in Fig. 13(C). This variation, which established high and low limits, attempts to simplify the inspection methods. However, the deviations liberalize the standards which can be harmful if not fully analyzed for each application.

System to avoid paradox of AGMA interpretation: With strict interpretation of the AGMA standard, some gears at the small end of the size limit are rejected although on the average they are of better quality then the minimum acceptable gear. This situation has been recognized by some manufacturers and has been circumvented by specifically accepting gears whose traces have low TCE, but whose average value falls between lines −0.0034 and −0.0039 in Fig. 12(B). Thus the rejected gears in the figure would be acceptable.

In practice this system is significant only when the size class of the gear is very close; otherwise the additional tolerance gain is small. Also, inspection of the gears becomes more involved because the inspector must analyze the curve to determine the mean value. This is subject to personal variation and becomes difficult as the plots vary away from simple sinusoidal forms.

Converting from One System to Another

Because gear size is not universally specified by the same method, it is important to be able to convert data accurately from one system to another. Thus, if a gear is specified by an over-pin dimension, it may be required to know its size when using the center distance method. Theoretically, a gear should measure to the same size regardless of the specific method employed. The reason different methods may not result in the same numerical result is usually the misuse of gear mathematics and practical dimensional variations in the gaging methods.

Consider a gear whose size is specified by an over-pin dimension and tolerance. By calculating the tooth thickness at the nominal, it is possible to calculate the center distance when meshed with a master gear or rack. A tolerance can be placed upon this dimension which would be consistent with the original tolerance on the over-pin dimension. However, if the gear has runout and tooth-to-tooth error, the resultant TCE will cause the center distance readings to vary. Only the average value of the center distance is equivalent to the over-pins measurement.

Many of the discrepancies when converting from one system to another are not caused by human error or lack of skill, but possibly by one of the following conditions:

Undersize Test Mandrel: If the gear has a bore larger than the mandrel diameter of the center distance testing fixture, the spring loading will force the gear to one side resulting in an incorrect smaller reading of center distance.

Micrometer Pressure: Correct over-pins measurements are usually dependent upon the sensitive use of a micrometer. Since line contact of fine pitch gears, often of soft materials such as aluminum, is subjected to micrometer pressure, variations of several ten thousandths of an inch in the reading are quite possible. This usually cannot occur with a variable center fixture which is spring loaded.

Averaging Effects: Continuous measurement with the center distance method gives a truer average size measurement than the over-pins measurement which spot measures a specific diameter that is subjected to minor profile variations, discrepancies caused by random dirt, and the surface finish of the tooth profiles.

Formula Errors: The approximate formula, Eq (1), used for relating backlash to the change in center distance can contribute errors of several ten thousandths in the case of large backlash ranges, particularly for small pinions.

Master Errors: The masters used in the center distance method may contain errors which blend with the gear under test, thus contributing an error of measurement.

Because the conversion between measuring systems is subjected to discrepancies which are not entirely avoidable, gear design and inspection should be bound by only one chosen system. Other methods may be used as a helpful reference and check, but always with the knowledge that full correlation may not be achieved. The unaltered AGMA system is desirable as a functional specification because of its basic flexibility. In addition, it is to everyone's advantage to foster a universally accepted system.

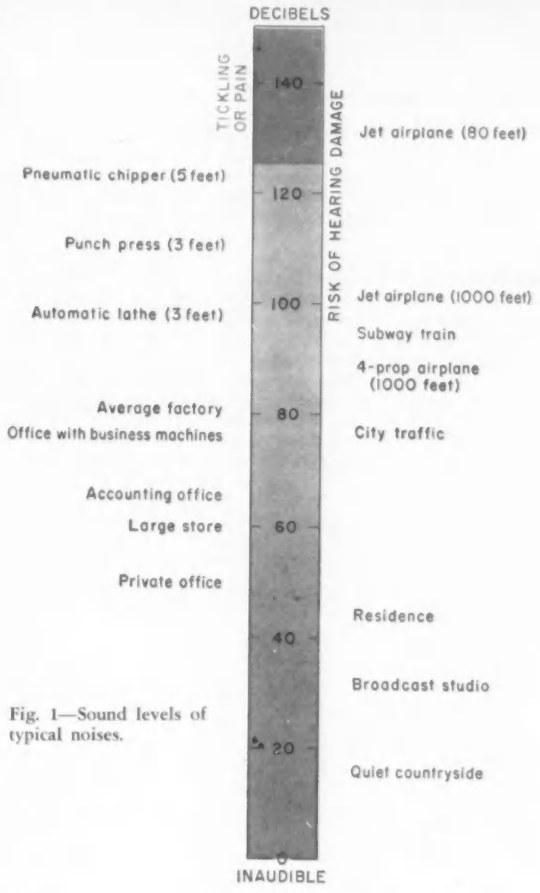


Fig. 1—Sound levels of typical noises.

NOISE CONTROL

A review of the terminology used to describe noise, its sources and control by insulation, isolation and absorption. The three major steps of a noise control program are outlined: analysis of existing noise, determination of desired objectives in terms of quieting, and implementation of the acoustical engineer's recommendations.

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Cambridge Acoustical Associates, Cambridge, Mass.

NOISE MAY BE DEFINED AS UNWANTED OR DISTURBING SOUND. This statement usefully stresses that the importance of noise lies in its effects, physiological and psychological, upon people. In the industrial environment, noise control is concerned with reduction of sound disturbance generated by people and machinery in the plant and by the product after sale.

Loud noise may damage the hearing of people who are exposed to it; the effect is cumulative over periods of years. Employers have been held financially responsible for even partial hearing loss induced by such occupational hazards. Loud noises incident to plant activities have led to successful suits for injunctions by nearby residents. Beside these legal aspects, proper control of plant noise can lead to greater efficiency, reduction of fatigue and general improvement of working conditions.

In addition to plant applications, noise control techniques can often be of great benefit when applied to the product itself. The least critical consumer can use generated noise as a basis for comparing competitive products and this may be a determining factor in his choice.

Specification of Noise

There are two aspects to the specification of "amount" of noise. The first is purely physical: what measurements are made. The second aspect is psychological: what effects do noises of certain measured amounts have on people?

The basic physical yardstick for noise is the decibel, which is essentially a measure of sound energy. A difference of one decibel is approximately equal to the minimum audible change in sound loudness. The overall sound levels, in decibels, produced in some typical situations are indicated in Fig. 1. The scale ranges from the threshold of hearing (at 0 decibels) to sensations of tickling (at 125) or actual pain (at 140) in the ear. For sound levels above about 90 or 100 decibels there is risk of a significant loss of hearing in any person who must work continuously in this environment.

However, to the acoustical engineer, the overall sound level is only part of the picture. It is essential to determine the noise spectrum, that is, the distribution of sound energy over the audible frequency range. Many of the ef-

Designed for Noise Control

PNEUMATIC TOOLS

Pneumatic tools are one of the most objectionable noise sources in manufacturing areas. The noise is mainly of aerodynamic origin. Chipping hammers, riveters, and grinding wheels also generate sound by vibration of the casting or plate which is being worked. The latter source of noise is particularly important when the work involves large surfaces, such as extensive castings or boiler plates, which form efficient sound radiators. Noise from this origin can be reduced considerably by loading the metal surface down with sandbags.

Aerodynamic noise can be controlled by interposing various sound attenuating devices between the exhaust ports and the atmosphere. This must be accomplished without giving rise to excessive back pressure which would reduce the efficiency of the tool. The most commonly used attenuating device is a simple expansion chamber inserted in the exhaust line. The lower the frequencies which are to be absorbed, the longer the chamber must be. For example, a 1000 cps component requires a chamber length of 3 in. The ratio of the cross-sectional area of the chamber to the area of the exhaust line should be as large as possible. (A ratio of 16 results in 20 db decrease of the noise level).

The exhaust noise problem of pneumatic hammers has been successfully handled in a different way at the General Electric Co. The simple device used is an exhaust collector ring in the form of a sleeve surrounding the exhaust ports. Exhaust air is collected in the annular area between sleeve and hammer. Noise was further reduced by exhausting the air through a long hose connected to the collector ring. Additional improvement might have been obtained by inserting an expansion chamber of the type described above.

OUTBOARD MOTORS

Military requirements and legal pressure have been two important factors in developing relatively silent outboard motors. Noise generated is partly of aerodynamic origin (exhaust and carburetor intake), and partly caused by engine vibrations which excite extended surfaces (hull of boat and fuel tank) like sounding boards. The reduction gears constitute a less important source of noise.

Exhaust is silenced rather efficiently by locating it under water. Further improve-

fects of noise are strongly dependent upon the frequencies involved. For example, noise predominantly low in frequency does not interfere with speech as much as the same amount of high frequency noise. When both low and high frequency noises are present, a great improvement can be achieved by reducing high frequencies although the overall sound level may be only slightly changed. Techniques of noise control depend strongly upon the spectrum of interfering noise and it is generally easier to control noises of high frequency than those of low frequency.

A growing body of information is available on the psychological and physiological effects of noise on man. It is completely impractical to make machinery inaudible, but how quiet should it be made? The goal might be to reduce noise to, or slightly below, background noise level in the area. Then additional disturbance from a new machine will not be significant. For example, the lathe manufacturer might consider the background level of an average factory (80 decibels on Fig. 1) to be his goal. Often such a goal can not be achieved. It is then necessary to determine the extent to which noise will disturb or interfere with operating personnel. Disturbance depends on amount of noise, its frequency spectrum and general character as well as the activities of people exposed to it. Different yardsticks are necessary for production line and for the accounting office.

Planning for Noise Control

Careful plant layout is the first move in a program of industrial noise control. Great improvements can sometimes be made by relatively minor changes in location of various plant operations. Different areas should be used so that each forms a buffer zone between next noisier and next quieter areas. In an aircraft engine plant test cells should be as far removed as possible from offices, while general manufacturing areas would be placed between the test area and the administration departments. The same principle applies within any one area. In a machine shop, noisiest operations should be isolated, wherever possible, from the remainder of the shop either by partitions, corners, or distance.

The noise control problem can also influence site location for new construction. An aircraft manufacturer planning a wind tunnel had best consider possible neighborhood reaction to the noise of powerful blowers operating day and night. Savings in avoidance of necessarily costly sound control measures in a thickly settled area may be well worth the inconvenience of locating some miles away in a sparsely populated region.

Consultation with acoustical engineers prior to installation or while architectural plans are still fluid can go far toward avoiding expensive modifications.

Control of Noise at the Source

Reduction of noise at the machine is an important first step in any noise control program. It is the only approach available to the machine manufacturer; the quieter his machine, the better it will sell, particularly on the consumer market. Noise is often associated with inefficiency and early failure. To the purchaser of industrial equipment, a quieter machine means less expense in acoustical treatment of the plant, greater efficiency and higher morale of his workers.

There are many sources of machinery noise. Fortunately, noise is not always inherent in proper functioning of equipment and therefore may be reduced without impairing machine usefulness.

Impact causes some of the worst noises. In a drop forge impact is the basis of the whole operation. However, impact of gear teeth in a loose or worn gear train causes noise which can be reduced without affecting function. For smaller loads, plastic gears which do not "ring" can be used.

Friction is another source of noise. Adequate lubrication in bearings will combat both noise and wear. Friction

ment might be obtained by the use of a muffler. Carburetor air-intake noise is controlled by means of a standard air-intake silencer as used on motor-car engines. Vibrations of hull and fuel tank are avoided by mounting the engine on flexible rubber mounts. Location and stiffness of the mounts must permit transmission of engine torque without excessive deflection. These are standard problems of vibration insulation. The motor cover should also be flexibly attached to the engine by means of rubber grommets.

Control of gear noise is primarily one of alignment, balancing and accurate machining.

ELECTRIC TYPEWRITER

A major source of noise in electric typewriters is the impact associated with the return of the carriage to the left margin. A remedy that can be usefully applied to many noise problems of this type is to cushion the impact by means of an air-cylinder and piston combination. IBM has spent much effort in developing an efficient piston-cylinder system for its typewriter. Several successive design changes were made in developing an effective device. A plastic cylinder was found preferable to an aluminum cylinder because of reduced machining costs; dry lubricants and silicone rubber piston rings are inferior to light silicone lubricants and leather gaskets because they give rise to binding.

HOUSEHOLD REFRIGERATOR

Main sound source in refrigerators is the motor-compressor unit, which is contained in a sealed housing. As in the case of the outboard motor, vibration of this rotating machinery must not be allowed to excite large surfaces that would constitute efficient sound radiators. Sides of the cabinet and evaporating pan must be kept quiet. This can be accomplished by flexibly mounting the rotating machinery.

However, noise is also generated by compressor piston action. Noise from this source is controlled by using intake and exhaust mufflers. In order to avoid reverberation of the air enclosed by the compressor housing, it is necessary to introduce sound absorptive material in this cavity. As is the case with most sealed units, the use of glass or other fibers is not advisable because of the possibility of fibers sifting into the machinery. Wire cloth is an acceptable substitute.

is inherent in the operation of planers and millers but milling involves less friction and less noise.

Unbalance is responsible for much noise in rotating machinery. Better static and dynamic balancing and more careful alignment will reduce noise and yield extra dividends in reduced wear and failure.

Aerodynamic noise originates in high speed flow of gases. Lower flow velocities reduce this noise and small reductions in velocity will pay big dividends in noise reduction. This should be considered particularly in the operation of pneumatic hammers and similar equipment. Frequently nozzles generate unnecessarily noise which can be reduced by simple redesign. Changes in design of blades and housing of a blower, to promote smoother air flow, can markedly reduce noise.

Electric noise such as from transformer hum, is common. Unbalanced magnetic forces in electric motors can cause vibration and noise as readily as unbalanced masses.

Even when noise is inherent in machine operation it may be confined within the equipment or reduced in intensity. This is achieved by obstructing or interrupting the path by which the noise reaches the ear. Many paths are usually involved; their identification and determination of their relative importance are the first steps toward noise reduction.

If the most important path is air-borne, closure or reduction in area of the openings will do much to eliminate that noise. A heavy gear box will effectively cut out sounds from enclosed gears. Openings in the housing are often essential to satisfy ventilation or other requirements, but small openings and cracks reduce sound insulation to a surprising degree. In such cases sound insulation can sometimes be achieved by use of sound absorptive materials and narrow duct-like passages.

When sound is structure-borne as when it travels from its source to the air along a metal structure, it may be interrupted by means of a resilient link, such as a felt or rubber pad interposed between two metal members. This technique is closely connected with vibration insulating devices discussed below. In some instances a change to less rigid connections between parts of the machine may reduce transmitted noise.

Large flexible panels, like those used as part of an enclosure, often cause high noise levels; they act like loudspeaker cones, facilitating the radiation of sound. This situation can often be remedied by coating the panel with a mastic vibration-damping material; an approach which has been successful in the automobile industry. Stiffening the panel, changing its mounting, and using several small panels for one large one are other remedies.

Resonance occurs when some part of the machine vibrates easily at one particular frequency of a disturbing vibration. This vibration may actually be larger than the disturbance driving it. Resonance often results from an improper use of flexible vibration isolators. Resonance must be strictly avoided.

Noise Insulation

When the design of the machine is fixed so that noise cannot be reduced at the source an insulating enclosure may be effective. This is particularly applicable where there is one noisy machine in a relatively quiet area. The insulating enclosure relies upon the mass of the walls to reduce transmitted noise. A special construction of two unconnected or flexibly mounted light walls may be economically preferable to the single heavy wall. Special attention must be paid to doors and windows—weak points as far as noise is concerned—and cracks and openings should be sealed wherever possible. For example, cracks around a loosely hung door may transmit as much noise as the door itself.

Many machines cannot be completely enclosed and it is necessary to resort to partial enclosures. For example, an enclosure around a noisy air compressor must have an opening for fresh air yet a hole would destroy most of the effectiveness of the box. In this case sound absorptive material inside the box and a properly designed short

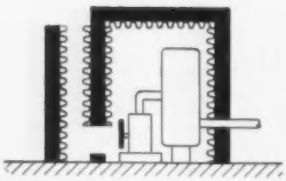


Fig. 2—Compressed air supply in enclosure with ventilating duct lined with sound absorptive material

Fig. 3—Jet engine muffler successfully reduced engine noise to that of local automobile traffic. Made of steel covered with protective fiber glass, muffler was developed by Industrial Acoustics Co. of New York for Republic Aviation Corp.

ventilating duct, lined with absorptive material as shown in Fig. 2, will solve the problem.

Jet engines and supersonic wind tunnels operated in urban areas are extreme examples of noise sources requiring partial enclosures. In reality these enclosures are overgrown mufflers, very carefully designed. An example of these is shown in Fig. 3. Typical jet engine test cells require mufflers about twenty feet long. In the case of the new NACA supersonic wind tunnel it was necessary to add a complex muffler system 33 feet wide, 46 feet high and 220 feet long.

In production areas, where ready access to a noisy machine is necessary, partial enclosures can significantly improve the noise situation without hampering operations. For example, walls partially enclosing a punch press, combined with sound absorptive material, can strongly reduce the amount of high-frequency noise—the "sharp" sounds —which reach neighboring installations. Besides reducing tension and fatigue, such an improvement will make conversation and the transmission of orders much easier.

Vibration Insulation

A vibrating or impact machine, rigidly bolted to the floor, can generate unbearable noise in the room below. Vibrations transmitted to the floor travel through structure in horizontal and vertical directions to create remote disturbances. Concrete slab construction is a particularly good transmitter of vibration.

A solution to problems of this nature is the introduction of a flexible structural discontinuity between the source and the disturbed area. The familiar vibration mounts are commonly used for individual machines. These are of several types: springs for the heaviest machines and when disturbing frequency is low; various kinds of rubber mounts; cork, rubber, and felt pads. Installation of these mounts under machine legs is easy and will markedly reduce the disturbance transmitted to the floor as shown in Fig. 4. However, the design of a flexible mounting system is a matter for expert consideration. Improperly used, the mounts can make the situation worse than rigid bolting by creating resonances and large vertical or rocking motions of the machine.

Another stratagem is the use of a floating floor. This is a thin slab of concrete cast over a flexible blanket of glass fibers, laid on the structural floor. A floating floor is called for when the relative alignment of several machines must be maintained, or when the vibration is generated directly in the floor by impact or rolling stock.

Sound Absorption

Sometimes there are so many different sources of noise that enclosures are impractical. In such a situation sound absorptive materials will reduce the build-up of sound levels somewhat. Sound that strikes hard room walls is reflected back raising the sound level and creating a disturbing and confusing situation.

Installation of sound absorptive materials on walls and ceiling performs two functions. It absorbs much of the sound that strikes it so that the sound level in the room is reduced. This reduction will usually amount to about 5 or 10 decibels, seldom more. However, because it absorbs high frequencies much more readily than low frequencies, reduction in disturbance and improvement in ability to understand speech may be very great. It also enables personnel to determine the location and approximate direction of the sound source, which is psychologically less of a strain than a general din which seems to come from all directions.

Sound absorptive materials come in many forms. Some are batts which can be used as concrete form boards, thus incorporating an absorptive ceiling in the construction. Perforated and fissured acoustical tiles are available. Glass and mineral fiber blankets can be installed behind perforated metal or board panels to make a hung ceiling.

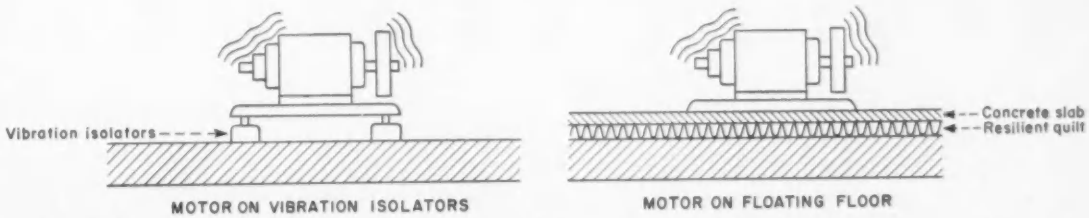


Fig. 4—Both vibration isolators and floating floors are used to keep vibrations of machinery from entering structural floor. Once vibrations enter floor, they can travel to other parts of the building to emerge as noise and cause disturbance.

Recently, many varieties of sound absorbers have been developed for easy suspension from a rough ceiling. These are more efficient than the same weight of material applied flat to a wall surface. Structural materials, such as cinder block, have been developed in special designs with holes leading to interior cavities combining sound absorption with standard structural characteristics.

Use of sound absorptive materials in an open room can help restrict the flow of noise to quiet areas. It cannot be expected to create an oasis of quiet in the middle of a large number of noisy machines yet it can reduce noise somewhat and will significantly improve working conditions of individuals in the vicinity.

Steps in a Noise Control Program

Once a noise problem is recognized and the desire for improvement expressed, what steps are involved in a noise control program?

First, it is essential to get information on just how much noise exists—its level and frequency spectrum—and what are its sources. It is not enough to say, "This pumping system . . ." or "This compressor makes the noise;" it is necessary to localize the initial source of vibration and the transmission paths it takes before radiating into the air. In product design, this analysis can be made, rather approximately, before the product is made.

Second step is to establish disturbance levels which will be the objective of the program. "Make it quiet" is not a practical statement of objective unless one really means "inaudible under any circumstances." Is the goal to provide negligible risk of permanent hearing damage, and if so, under what conditions of exposure? Shall noise levels be reduced until they are only mildly annoying to residential neighbors, or will strong complaints without legal action be tolerable? Should conversation be possible in a normal (or raised or shouting) voice and at what distance? Is telephone use in this area essential? Answers to questions such as these will enable the acoustical engineer to formulate physical standards for noise conditions after correction.

Finally, the acoustical engineer can develop plans for quieting of the machines or area involved. These plans may be quite straight-forward or several alternative methods may be possible which will have to be evaluated on an economic basis, possibly with a review of the objectives that have been set. Frequently experimentation will be necessary in order to get further information about the sources of noise and the means for overcoming it.

End result will be a quieter and safer environment in which work may be performed more efficiently and with less disturbance to workers and to neighboring areas.

EDITOR'S NOTE—Elimination of undesirable noise or vibration takes an important place in the design of any product. In recent months *Product Engineering* has published articles on these subjects that may be divided into two major categories.

Damping Materials and Vibration Isolators

"Vibration Damping Characteristics of Glass Fiber Cushioning," Sol Musikant, Feb. 1954 p 166. Resiliency and damping properties, shear strength, temperature range and design recommendations.

"Damping Capacity of Materials," Alexander Yorgiadis, Nov. 1954 p 164. A practical approach for analyzing and evaluating damping capacity in uniformly and nonuniformly stressed members.

"Vibration Isolation of Equipment with Eccentric Centers of Gravity," Sheldon E. Young, Feb. 1954 p 146. Analysis of three-point, four-point, and six-point mounting of isolators.

"Shock or Vibration Isolators," J. Markowitz, June 1953 p 212. Types of forcing functions and ranges of frequencies that can be isolated by different classes of mounts.

"Selecting Vibration Isolators," Russell Lowe, Sept. 1955 p 184. Five point design procedure and drawings of 11 types covering loads from ounces to tons.

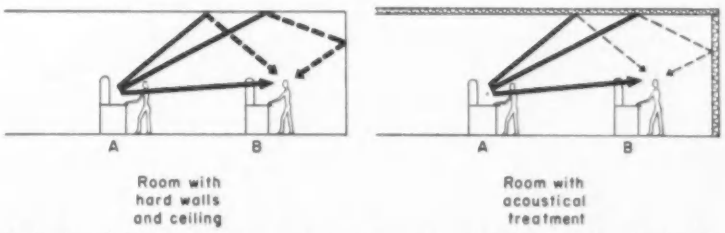


Fig. 5—Sound from machine *A* reaches operator of machine *B* both directly (solid arrow and by deflection from ceilings and walls (broken arrows). Sound absorptive material on walls and ceilings reduces the amount of sound that is reflected. This does not affect sound heard by operator *A* from his own machine.

Noise and Vibration Analysis

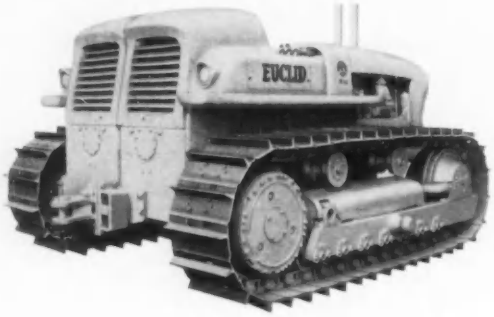
"Keeping Products Quiet," D. F. Muster, Dec. 1954 p 140. Physiological effects of noise; magnetic, air and mechanical noise sources in induction motors; methods of reducing noise to desired levels.

"Calculating Fundamental Frequencies of Machines on Flexible Structures," Walter W. Soroka, April 1954 p 190. Equations for determining flexibly-supported cantilevers, composite structures, vibration isolation and transmission to wall or floor.

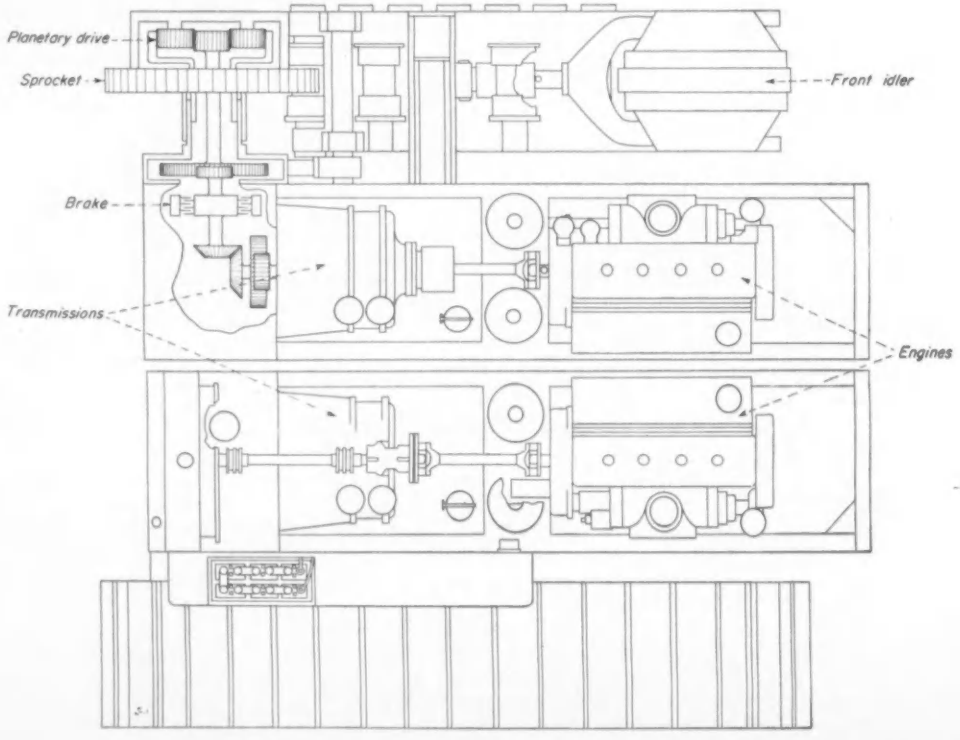
DESIGN FEATURES

Separate Track Drives Make Tractor Maneuverable

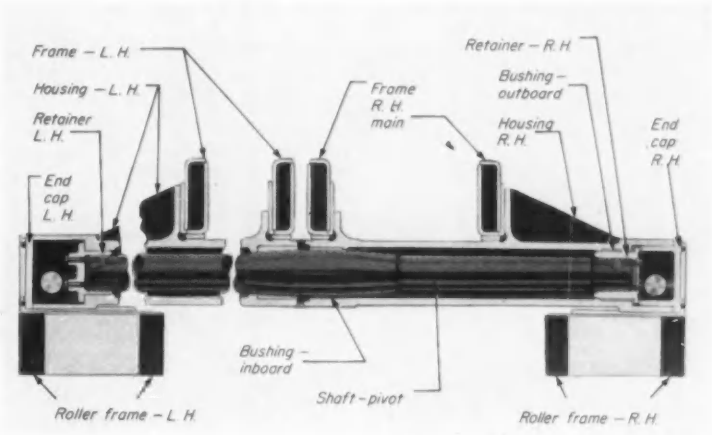
Engineers at Euclid Division of General Motors Corp., Cleveland, Ohio, have used a new approach to crawler design by driving each track with an independent power train. Engines, transmissions, and cooling systems of the TC-12 tractor are in twin frames which pivot on a connecting shaft to increase traction on uneven ground.



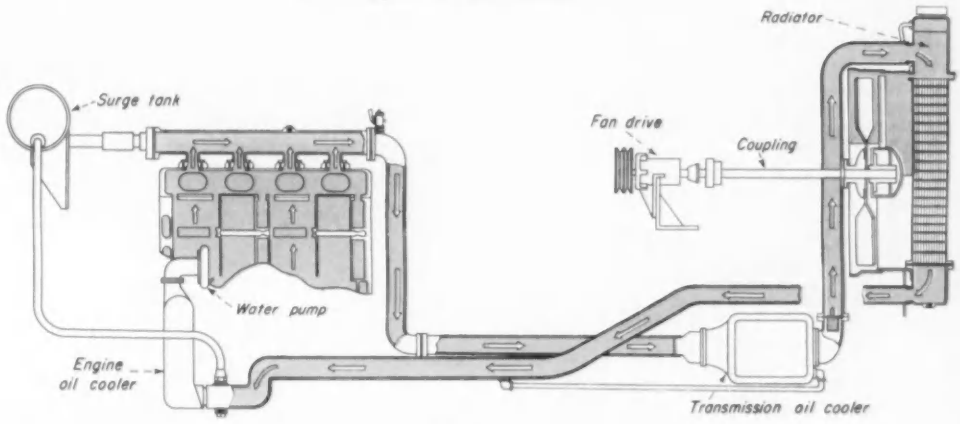
TWIN CONSTRUCTION makes it possible to steer and apply power simultaneously and allows use of power components previously proven and in current production. When tractor was designed, no engine was available to produce needed power, so decision was made to use two existing 195 hp engines which gave lower cost per hp than if a new engine was developed. This principle was applied also to the torque converter and transmission to avoid developing special components for one size tractor. The smaller components can be used also in other tractor designs and give higher quantity part runs in production. Separate power trains make it possible to steer by running tracks in same direction at different speeds or to turn the tractor in its own length by running tracks in opposite directions.



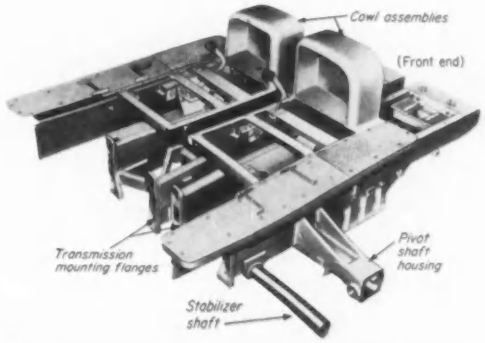
IN NEW PRODUCTS



PIVOT-SHAFT is 7 in. dia and 100 in. long. Building tractor in separate halves joined by shaft allows sections to oscillate so tracks can conform to rough ground. This also makes it possible to break the unit into two pieces for transportation in areas where 60,000 lb tractors can't be carried as one load. Shaft is made of non-alloy steel for low cost, but is heat-treated for surface strength in critical areas. It is locked to left-hand frame by tapered socket and retainer, but rides on non-extruding phenolic-plastic bushings in right-hand frame. These bushings have good bearing capacity and are not lubricated. Thrust washers at right retainer are also plastic.



▲ **COOLING SYSTEM** at rear of tractor gives operator better forward visibility as front hood is lower, and places radiator and fan where they are less vulnerable to dust and mechanical damage. Fan drive is taken from pulley on transmission input flange, and engine heat blows out back of tractor without reaching operator. Water cools transmission and engine oil while on way to radiator, so no oil piping is used. Air is drawn down through a grill behind operator's platform and blown out through radiator core to rear of tractor. Each tractor-half has a complete closed circuit system for cooling engine, engine lubricating oil and converter-transmission oil. Radiator is hinged to drive case and is tilted back out of the way to provide access to the transmission.



▲ **FRAMES ARE MADE** of weldments to get strength and rigidity at lowest cost for small production quantities. Superstructure is welded to frame with transition elements to give sufficient flexure in mountings to prevent stress concentrations at welds. Front portions of each frame support engines; rear portions support torque converters and transmissions. Final drive cases bolt to flanges at rear of each frame which are part of solid ends of box-beam side members. Fuel tanks are below and forward of cowl and dash assemblies. Pivot-shaft housing is a steel casting welded into the frame, and stabilizer shaft and pivot-shaft housings connect main frame to track roller frame.

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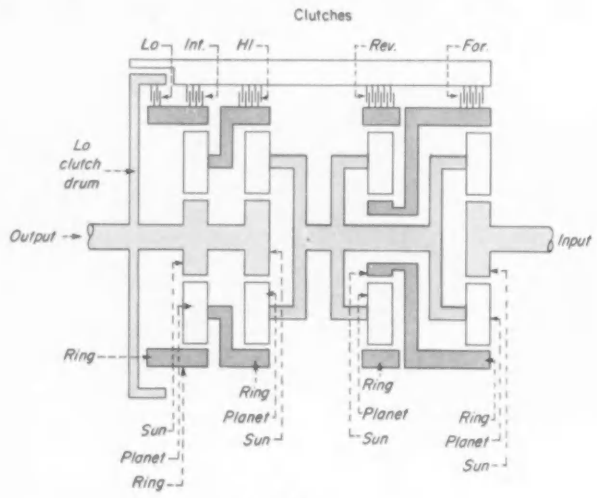
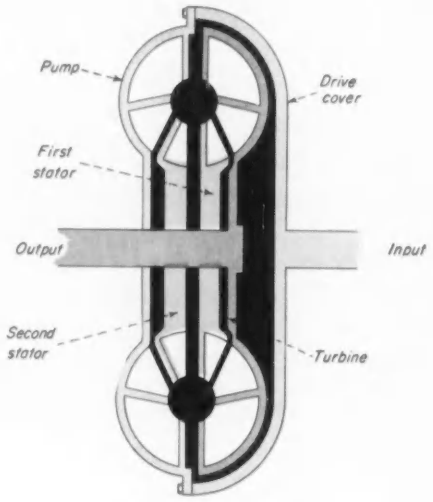
Tractor (continued)



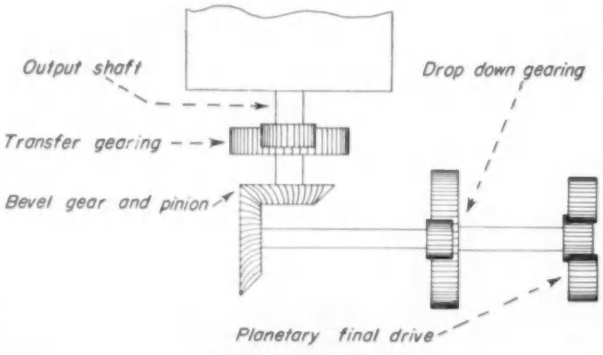
Transmission



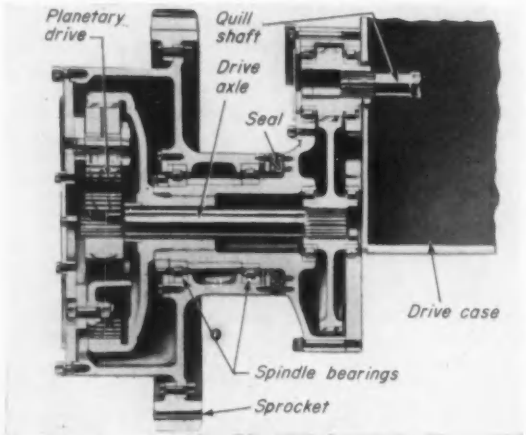
Torque Converter

SINGLE-STAGE POLYPHASE TORQUE CONVERTER was selected to obtain high efficiency at low loads and allow power shifting of planetary transmission. In this design, ability of stators to rotate with turbine makes unit act as fluid coupling when torque requirements are low. Transmission consists of a forward and reverse, constant-mesh, compound-planetary gear unit in combination with a 3-speed planetary type main transmission gear train. This gives operator 3 speed ranges in forward and reverse which can be selected without loss of motion. Clutches are hydraulic and are operated by selector valves connected by linkage to operators control levers. One lever selects speed, and a second, the direction of motion.

▶ **FOUR GEAR REDUCTIONS** are used between transmission and track. A transfer gear and bevel gear assembly is flange mounted at rear of transmission case. Drop-down gearing and the final planetary drive are outside tractor frame. Design keeps high torque at point of application, allows steering brake to be placed on a high-speed shaft, and makes it possible to take a winch drive off the transfer gear shaft. Hub of multiple disk brake assembly acts as coupling between cross-shaft of bevel gear assembly and quill-shaft of drop-down gearing.

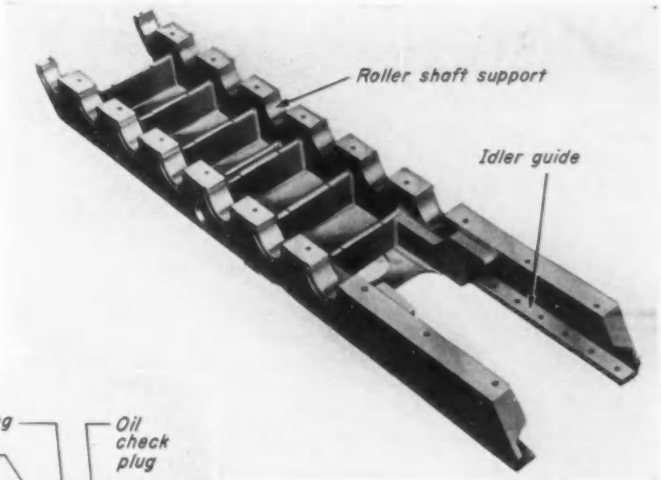


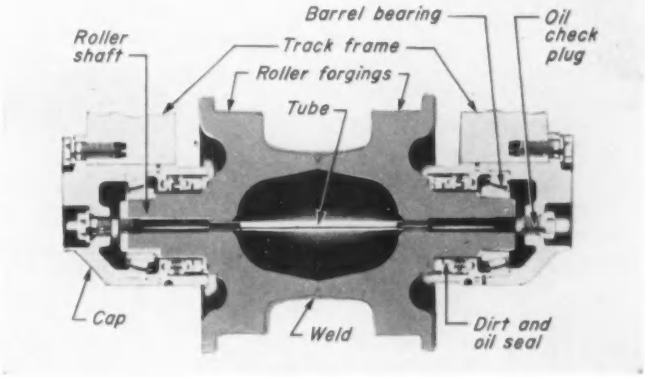
TRANSMISSION



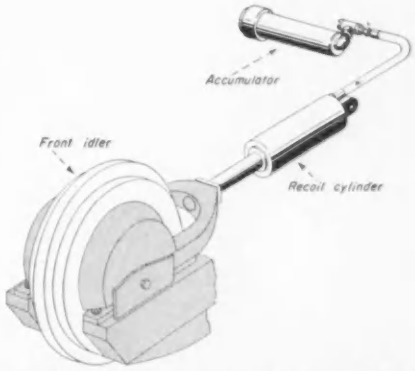
◀ **DRIVE AXLE FLOATS** in splined hubs of bull-gear of drop-down gearing and sun-gear of final planetary drive. Planet gears are mounted on drive flange cover and ring gear is splined to the axle spindle. Sprocket which drives track is bolted to driving flange. Planetary drive makes it possible to use smaller gears with narrow faces which operate with less tooth distortion.

TRACK FRAME is made from 3½ in. by 9 in. mild carbon steel bars about 120 in. long welded to ½ in. top-plate and web members. After assembly, side members are milled to support track roller shafts and guide the front idler and yoke assembly. Each track assembly is connected to tractor frame at pivot-shaft housing and stabilizer shaft so track and frame form a rigid assembly which oscillates on the pivot-shaft.

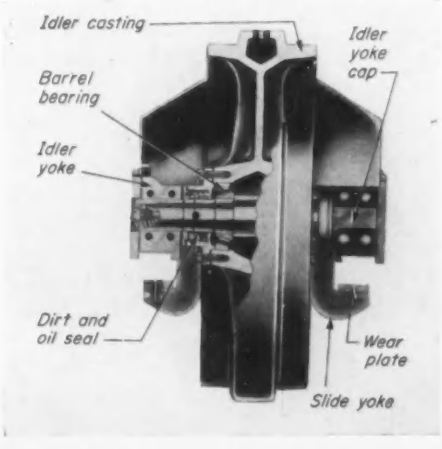




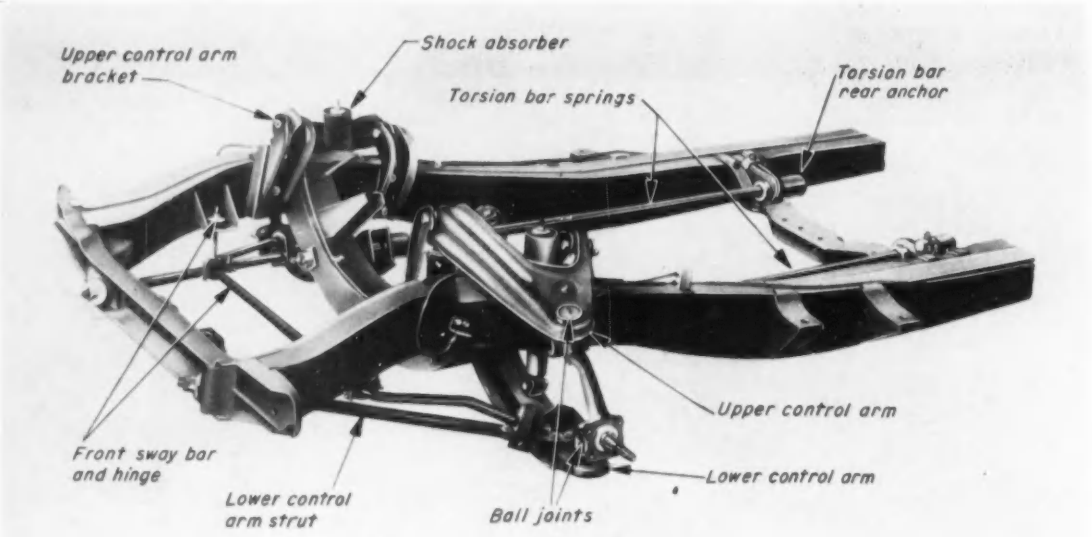
TRACK ROLLERS are formed by butt welding two steel forgings to make a low-weight, high-strength unit. Live-shaft construction avoids growth of bearing housing diameter from track impact loads by supporting bearing assemblies outside of rollers on track frame. Design also allows use of standard size roller bearings and spring-loaded lapped-face oil seals. Tube running through roller center allows lubrication of both bearings from either side.



TRACK TENSION is held to safe values by a hydraulic recoil cylinder which is connected to a nitrogen filled accumulator precharged to 1000 psi. Cylinder is connected to yoke which supports front idler roller and slides in guides machined in track frame. Shock loads cause yoke and idler to move backward and displace oil from cylinder into accumulator; system pressure forces yoke to forward position when abnormal load is removed.

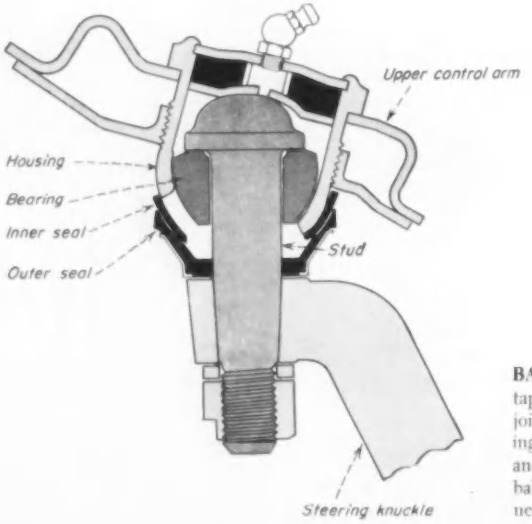


FRONT IDLER is a steel casting of spoke-and-rim design with bearings mounted in the hub. Unit rides on shaft held rigidly in the yoke. Wear plates on yoke ride slot in track frame and transmit vertical load components to tractor frame; horizontal load components are absorbed in recoil cylinder.



NEW SUSPENSION uses one forged steering knuckle supported by ball joints. Upper control arm is pivoted in rubber mounts at an angle for anti-dive control. Lower control arm is a single link braced to front of frame by a strut. Old suspension used two wishbone control arms and a forged yoke with kingpin and thrust washer to support the steering knuckle. Threaded bushings connected yoke to control arms and the arms to the frame.

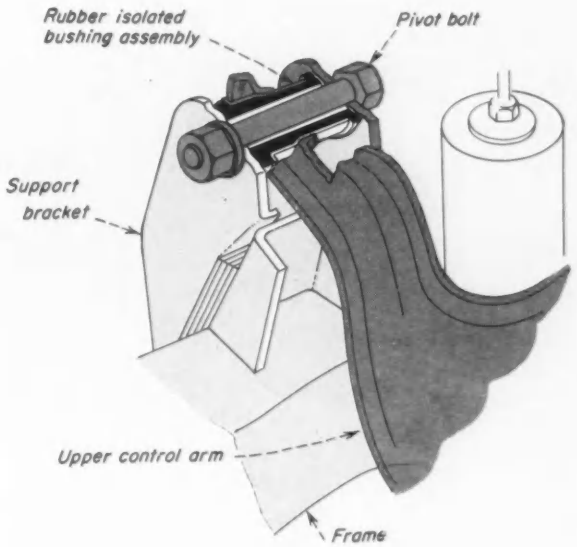
Rubber Isolation Decreases Shocks Transmitted to Frame

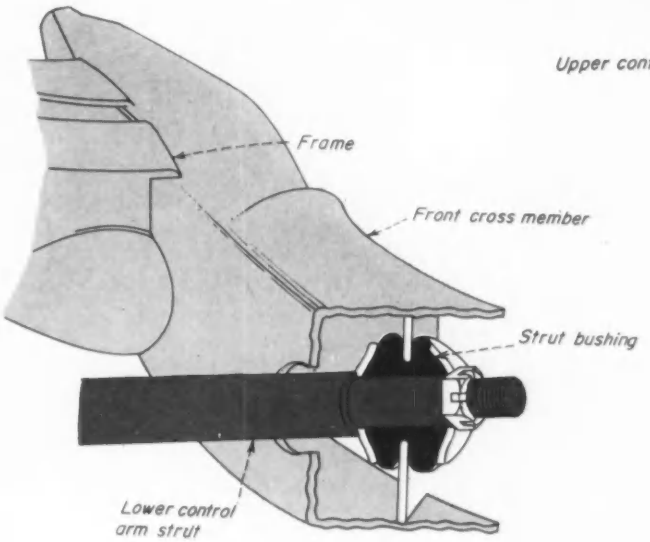


Rubber isolated bushings are at all points where front suspension members connect to the frame of the 1957 Chrysler. Points requiring lubrication have been reduced with this design which uses a ball joint suspension and torsion springs. Sintered bearings lubricate the ball joints, and nylon bearings are used in the steering linkage.

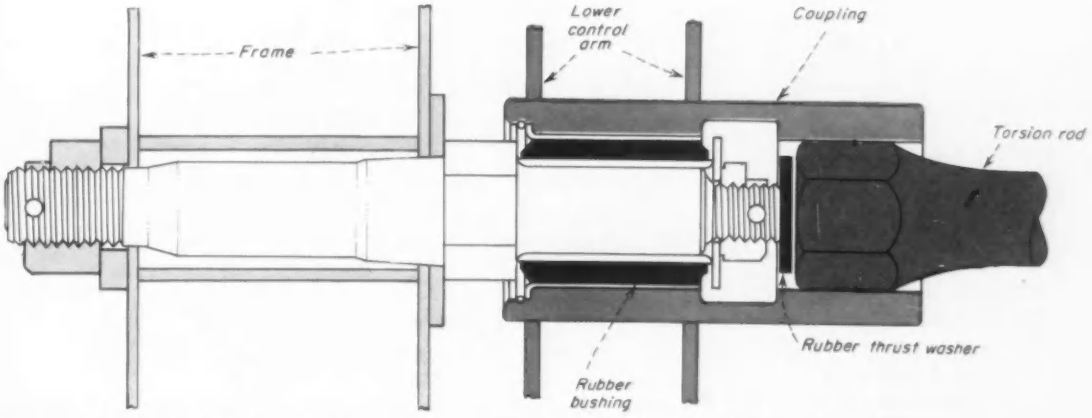
BALL JOINTS are held in steering knuckles by tapered studs. Sintered bearings, ride in steel ball joint housings in the control arms. The bearings are made of a mixture of steel and copper, and are oil impregnated. Hardened threads on ball housing are self-tapping to make tight connection with control arms.

INSIDE PIVOTS OF UPPER CONTROL ARMS are rubber isolated bushings. The rubber is pressed to the bushing and the shell, and resists control arm rotation by being stressed in shear for its whole length. Supporting pivot bolt at two points in frame divides load over two shear planes so smaller diameter bolt can be used.



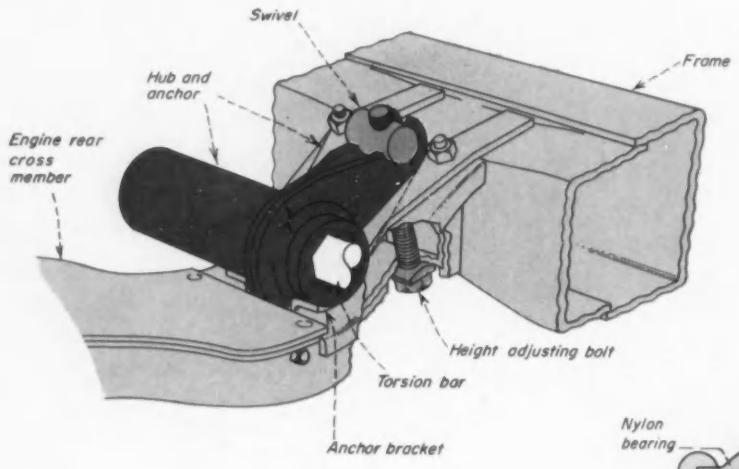


LOWER CONTROL ARM STRUT is held to front cross member of frame with a rubber isolated bushing, which reduces magnitude of shocks transmitted to frame by impact loads on the front wheel. Frame, lower control arm, and the strut from a wide-base triangle for rigid support of steering knuckle. Shocks produce tension in strut, rather than eccentric bending loads on the lower control arm.

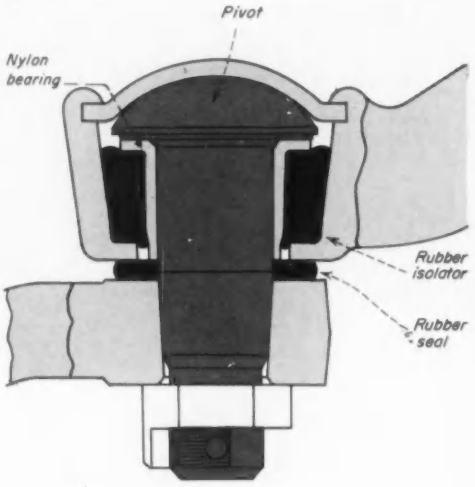


LOWER CONTROL ARM is supported on a stud by a rubber isolated bushing in coupling to torsion bar spring. Lower cost torsion bar is made by cold forming hex heads on bar stock which fit hex in couplings.

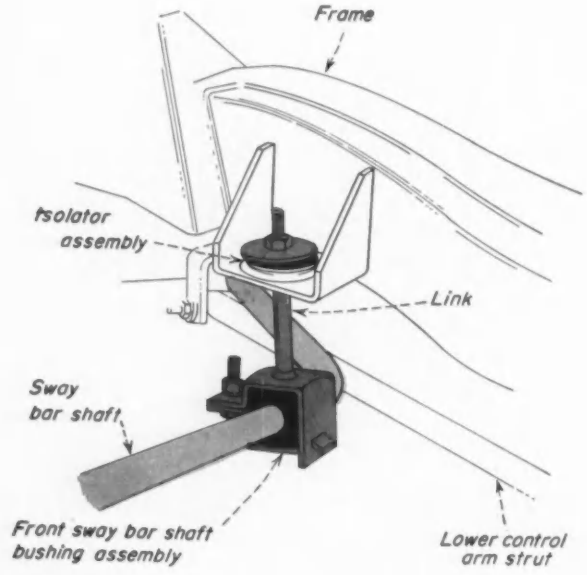
(continued on next page)



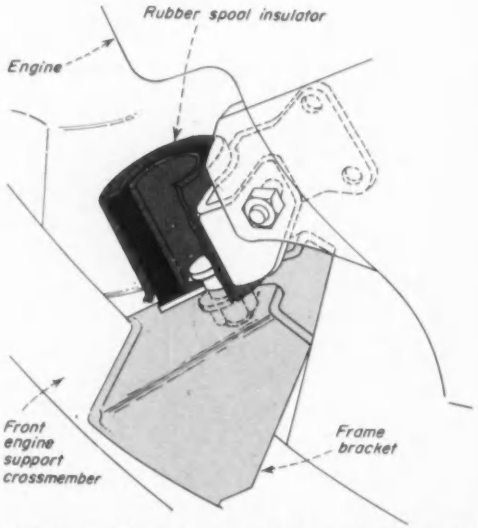
TORSION BARS are prestressed for height control with an adjusting screw at the rear anchor. Hex head on bar fits into hub, which rests on engine rear cross member and is welded to the anchor bracket. Eccentric load applied to bar by adjusting screw and swivel produces torque to support the car and reaction force which holds the hub to the frame.



NYLON BEARINGS supported on preloaded rubber bushings connect the center link and arms of the steering gear. Steering idler arm is attached to frame with a rubber bushing and bolt in same way as upper control arm, but tie rod bearings are lubricated. This design reduces points requiring lubrication and dampens road shocks transmitted to steering wheel.



SWAY BAR is suspended with links supported in the frame by rubber isolators. Rubber isolated bushings are used also where the links connect to the sway bar and where the bar connects to the lower control arm strut.



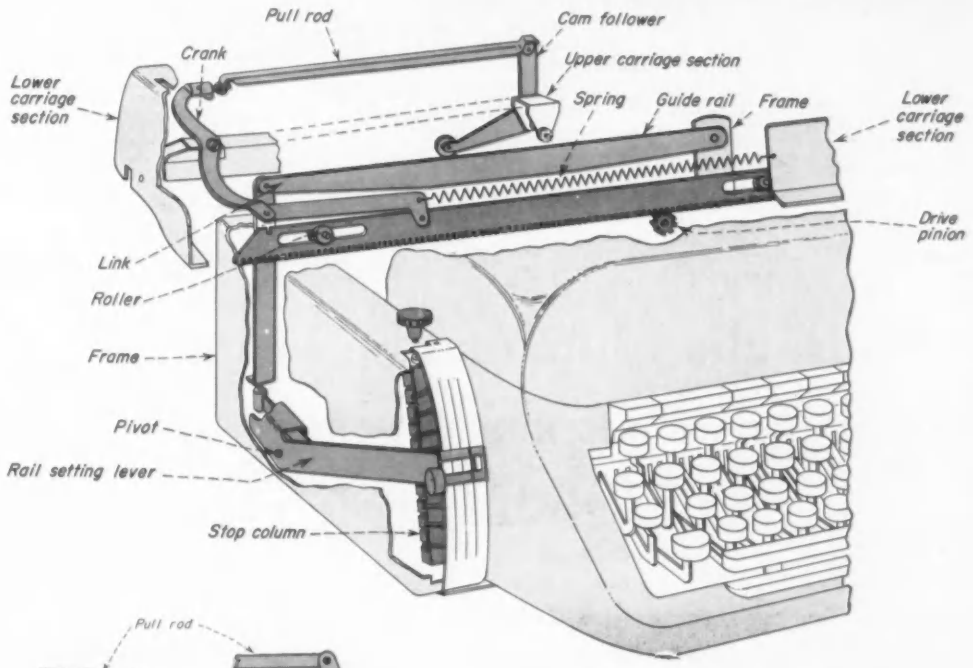
RUBBER SPOOL isolators support the engine. Horizontal motions compress the rubber and meet high resistance, and pitching and rolling movements are resisted by greater axial deflection of the cylinder in shear.

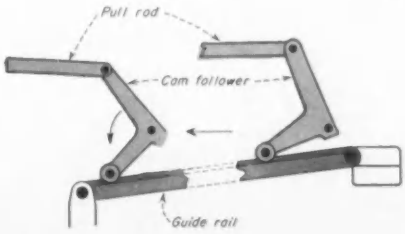
Two-Section Typewriter Carriage Makes Even Margins

Margins are justified automatically in a typewriter made by Adlerwerke, Frankfurt, Germany. Making the carriage in two sections, which move relative to each other, allows cam driven linkage to change letter spacing and make margins even.

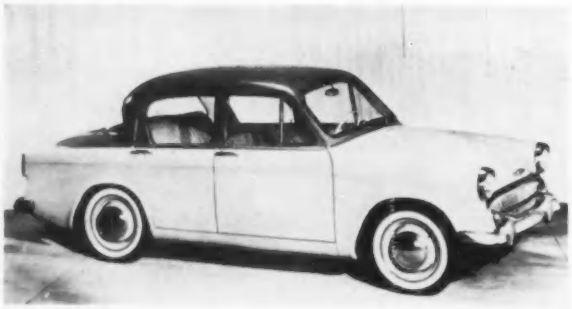
A DRAFT IS TYPED and positions of line-endings are read from scale on overhead bail. This scale is divided into four sections, one for each side of the slotted stop column. Each line of copy is then retyped with rail-setting lever and stop-column set to scale reading taken from bail.

Lower carriage section rides on rollers in slots in the drive rack, and is pulled toward left end of slots by a spring. Upper and lower sections are connected by linkage positioned with a cam follower, which rides a guide rail pivoted in the frame. Guide rail angle is set by positioning rail-setting lever in slots in the stop-column.

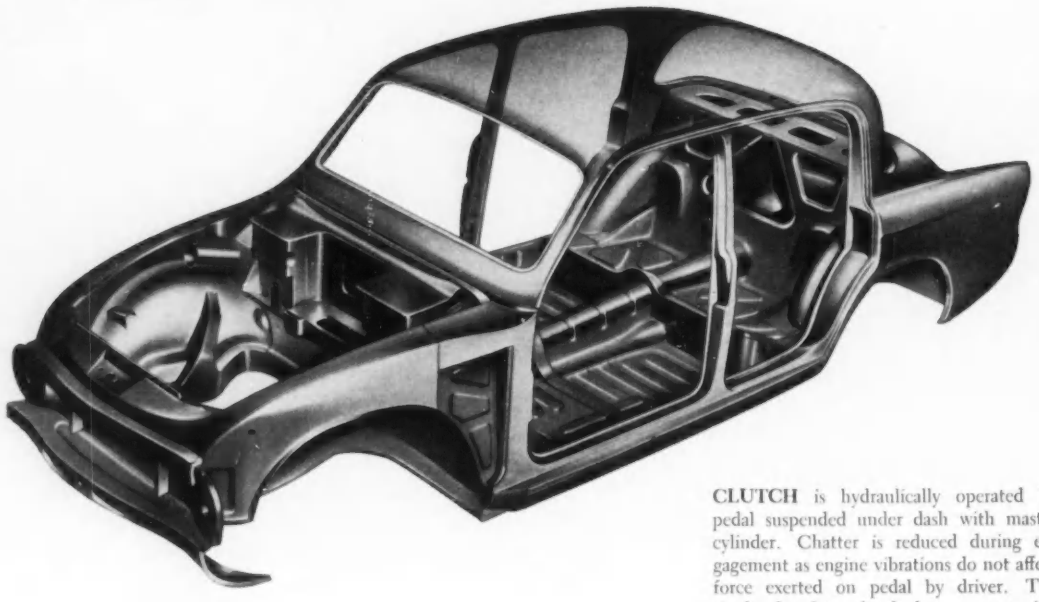




SLOPE OF GUIDE RAIL is determined by position of setting lever in slotted stop-column. As carriage moves across frame, cam follower is rotated by sloping guide rail to continuously change relative position of carriage sections. As the rail slope for each line is set according to scale reading, spacing of letters is adjusted to keep margin uniform.



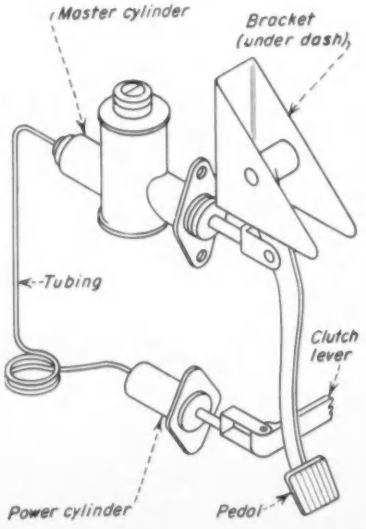
CHASSIS UNIT is made of light gage sections welded into a box-like structure for low weight and high rigidity. Deep shaft tunnel and box-sill sections reenforce the step-down floor and keep the center of gravity low. Front and rear suspensions, engine, and propeller shaft are pre-assembled on a jig and then lifted into the frame in one assembly operation.

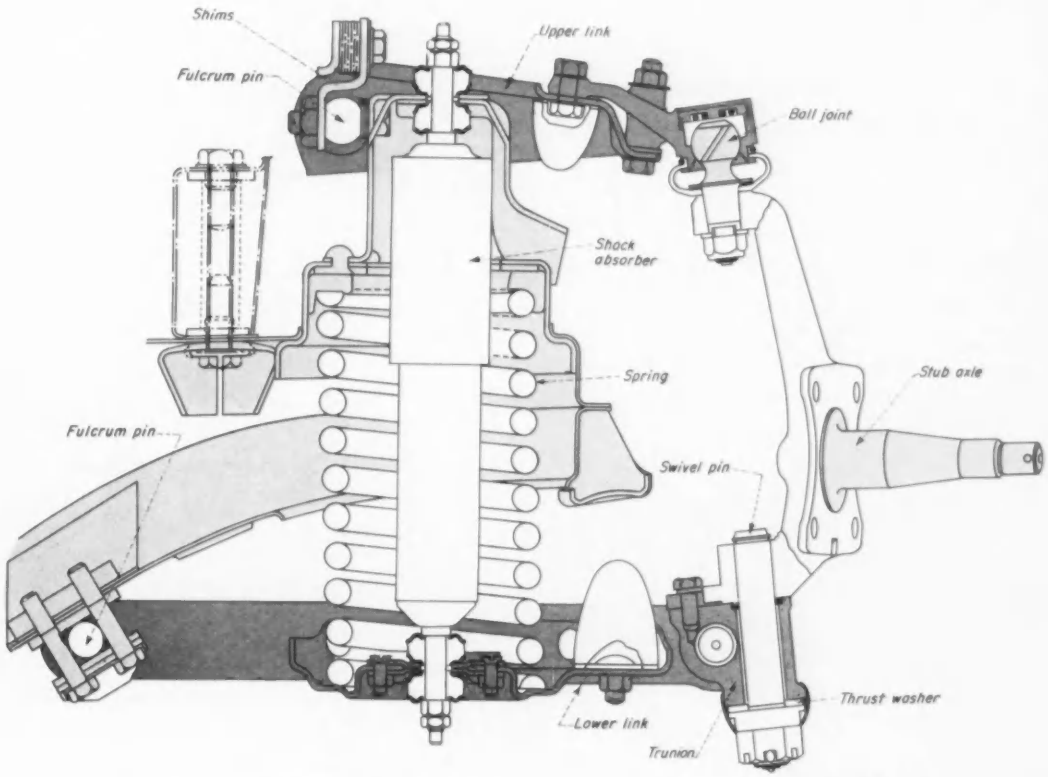


CLUTCH is hydraulically operated by pedal suspended under dash with master cylinder. Chatter is reduced during engagement as engine vibrations do not affect force exerted on pedal by driver. The single dry-plate clutch has a copper-impregnated graphite release bearing which is self-lubricating.

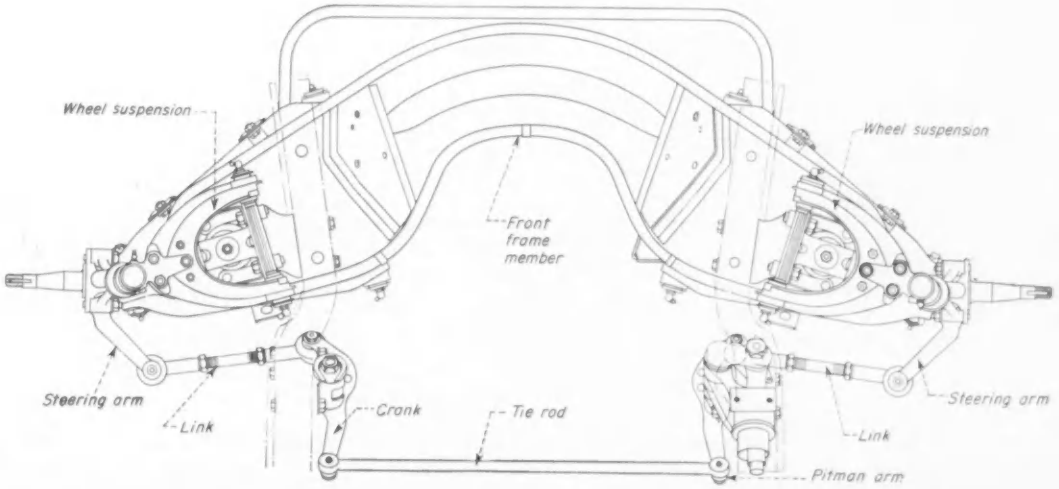
Hydraulic Clutch and Ball Joint Suspension in English Car

A hydraulic clutch release system that reduces chatter from engine vibrations and a ball joint suspension with low unsprung weight are design changes in the 1957 Hillman Minx. This car also has a one-piece welded frame, cam adjusted brakes and a rear axle machined from bar stock.

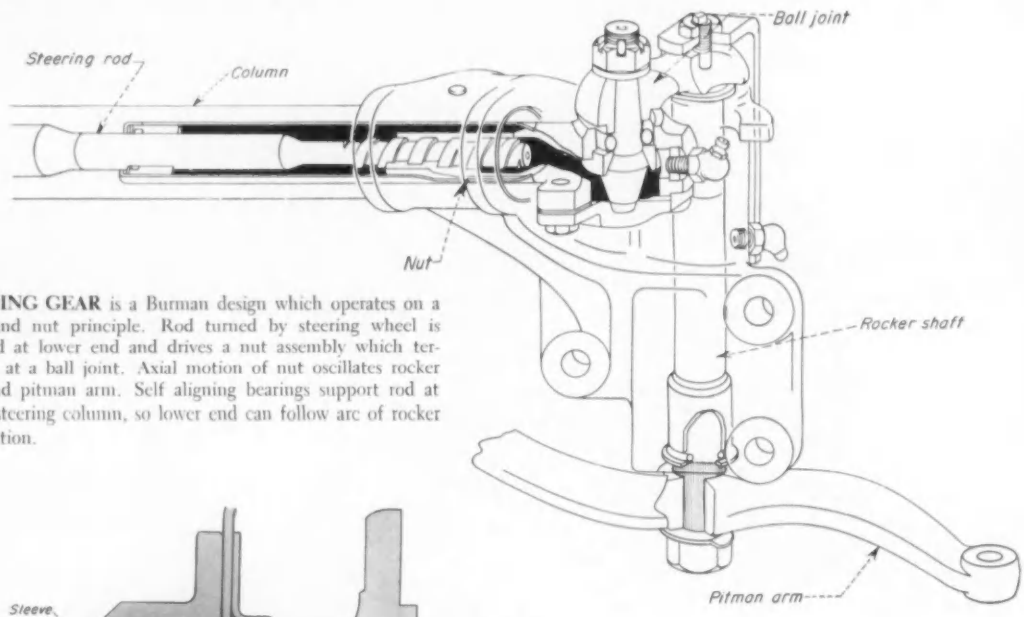




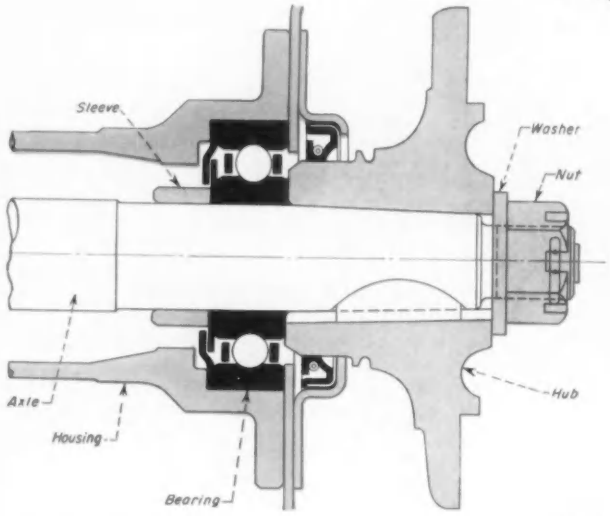
UNEQUAL LENGTH WISHBONE links and a coil spring support each front wheel, with single inner fulcrum pins connecting both ends of each link to the frame. Camber is set with shims placed between upper fulcrum pin and the bracket on chassis crossmember. Stub-axles support the wheels, and ride on a ball-joint in the upper link and a swivel pin and trunnion which pivots on the lower link. This design reduces unsprung weight by not using a separate stub-axle carrier. Thrust is transmitted by nut and washer to lower face to trunnion.



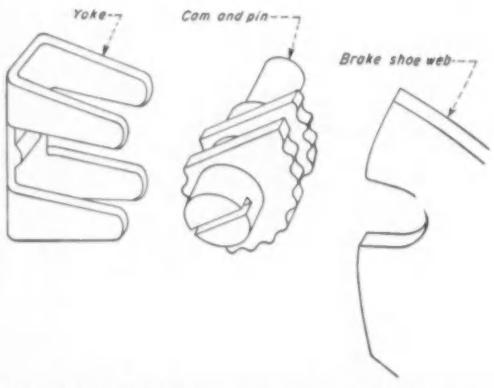
TIE ROD is behind engine and is connected to left wheel steering arm by a double-ended crank and connecting link. Pitman arm is also double-ended and is connected to tie rod and steering arm link of right wheel. This makes it possible to place engine forward in frame and increase space for passengers. *(continued on next page)*



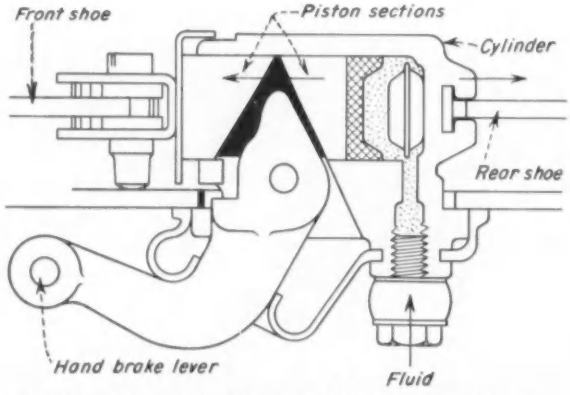
STEERING GEAR is a Burman design which operates on a worm and nut principle. Rod turned by steering wheel is threaded at lower end and drives a nut assembly which terminates at a ball joint. Axial motion of nut oscillates rocker shaft and pitman arm. Self aligning bearings support rod at top of steering column, so lower end can follow arc of rocker arm motion.



REAR AXLE is made of alloy steel bar stock, ground over its full length to reduce stress raisers. Differential end is splined to take bevel gear, and wheel end is tapered. Bearing backing sleeve is put on shaft in initial position about 0.080 in. from the final setting; then bearing and hub are placed on shaft and sleeve is squeezed to final position with a torque wrench and nut.



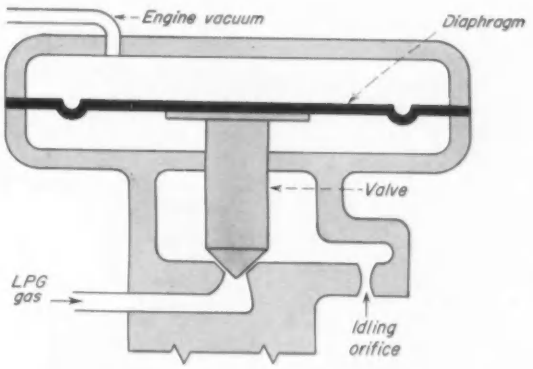
SHOE CLEARANCE is set by rotating a notched cam on a pin set between the shoe web and a yoke on the piston of the actuating cylinder. Cam has 2 lobes which ride on either side of web, and the yoke has a ridge which fits into a notch on the piston centerline. Rear wheel brakes have one adjustment, while two are used at each front wheel.



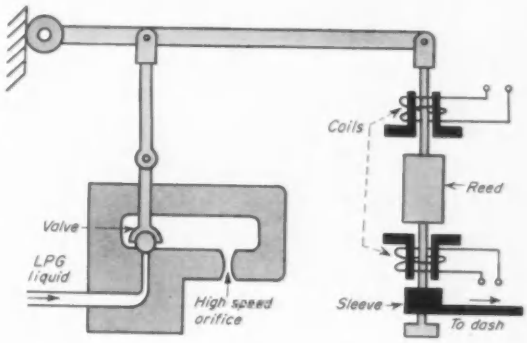
FLOATING HYDRAULIC CYLINDER in rear wheel brake applies pressure to rear shoe while piston forces front shoe against drum. Piston is in 2 sections which are notched for a cam operated by the hand brake. Hydraulic pressure forces both piston sections out against shoe; handbrake cam only moves outer section. Both shoes pivot against block fixed to back plate.

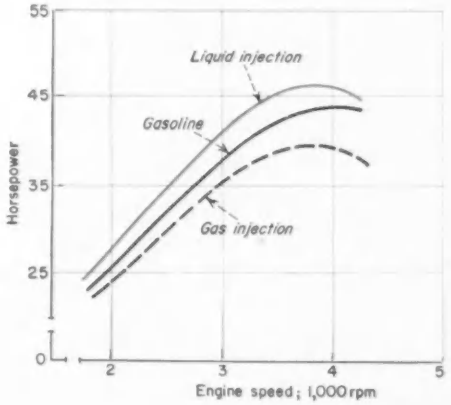
L.P.G. Carburettor Injects Both Liquid and Gas

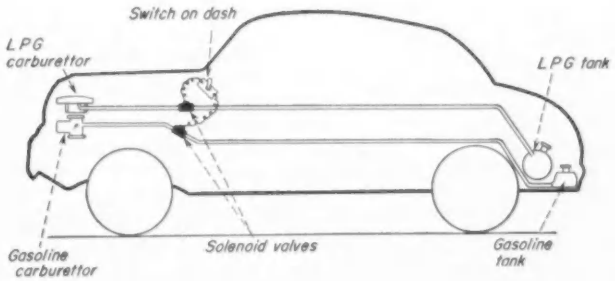
Gas is fed to the engine intake manifold when idling and liquid when running at high speeds by a carburettor developed at Officine Botto, Rome, Italy. A vibrating reed synchronizes injection of liquid with engine speed and bled gas cools it to avoid pre-vaporization in the carburettor.



THREE JETS FEED FUEL INTO THE MANIFOLD. A diaphram valve, operated by engine vacuum, regulates gas flow at idling speeds, while at high speeds, liquid is metered into the manifold with a valve positioning by a vibrating reed. Reed is driven by 2 coils alternately energized by cam driven contracts in the distributor. Quantity of fuel injected is set by positioning a sleeve on the reed to limit valve opening; sleeve is positioned by a lever on the dash. Cam rotation set basic injection timing to engine speed, while butterfly valve position and manifold vacuum advance this setting for higher speeds or retard it for accelerating by changing the clearance between cam and follower. Liquid bled from line in carburettor expands in an auxiliary chamber and cools the main fluid stream to prevent prevaporization; it then passes through a heat exchanger to cool air entering the manifold and is finally mixed with this air by the third jet. Gas injected by third jet smooths transition from idling to power operation when shut off valves in supply lines switch carburettor from vapor to liquid operation.



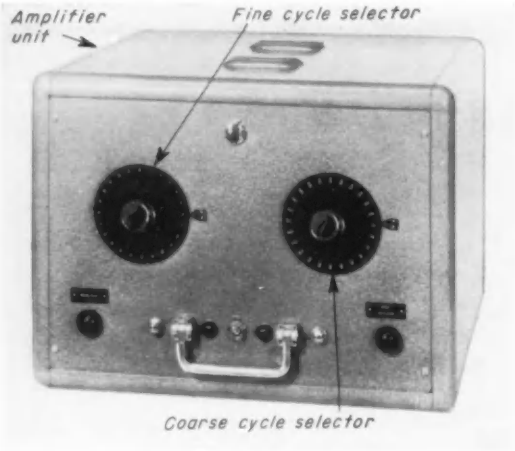




PERFORMANCE of Fiat 1400 engine with gasoline, and LPG fed only as dry gas compared to operation using Botto carburettor. Curves show 24 per cent power increase over gasified LPG, 13 per cent increase over gasoline and 32 per cent increase over methane. Liquid and vapor are tapped from supply tank with a dual-purpose pressure-reducing valve and piped to carburettor through concentric tubes. Center tube carries liquid while vapor passes through annulus.

For operation with two fuels, LPG carburettor mounts above gasoline carburettor in place of air filter; fuels are in separate tanks at rear of car and are selected with solenoid valves operated by switch on dash.

Air in the manifold is cooled by expanding LPG, causing a higher density mixture to be drawn into the cylinders. This produces higher gas temperatures and pressures which develop greater power output.



THREE UNITS form the system: the drive unit, which includes servo motor, the amplifier, which contains power supplies, servo amplifier, counting mechanism and relays, and the optical system, which includes light source, vibrating slit mechanism and photo-cell. System has been applied to indexing armatures of small motors for milling undercuts between segments of commutators but also works when reference lines are not uniformly spaced. Positioning accuracy is within ±0.003 in. Switch dials on amplifier preset number of indexing operations for automatic cycle; unit energizes light or other signal when preset cycle is completed.

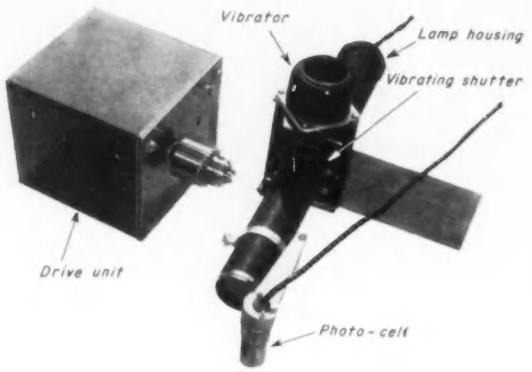
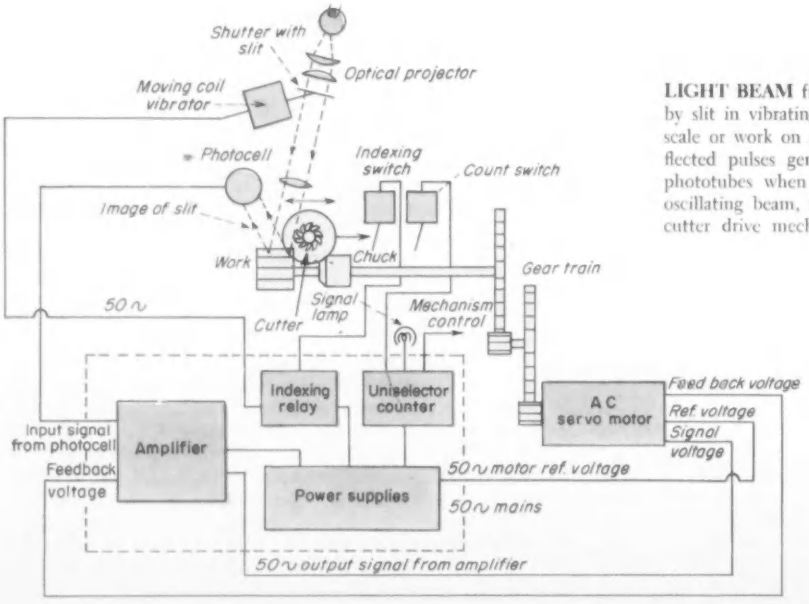


Photo-Electric Servo Indexes Commutator

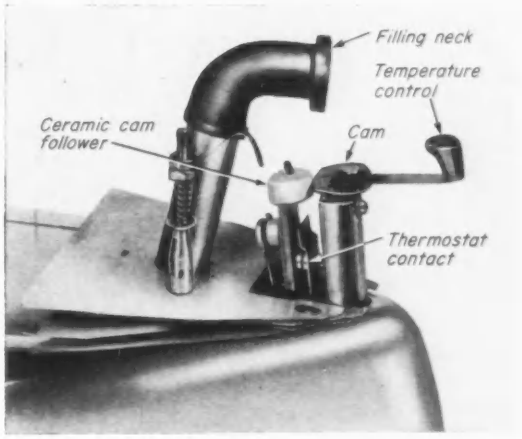
A device which automatically indexes circular objects to preset angular positions by centering a reference line in a light beam has been developed by Electronic & Musical Industries Ltd., Hayes, England. Effects of background illumination are avoided by using a vibrating light source which produces signals detected by a photo-cell.



LIGHT BEAM from optical projector is modulated by slit in vibrating shutter to alternately illuminate scale or work on either side of reference line. Reflected pulses generate equal amplitude signals in phototubes when line is centered in envelope of oscillating beam, then relay is energized to actuate cutter drive mechanism. On return stroke, cutter operates indexing and count switches, and starts work on next indexing cycle by energizing servo motor to rotate work toward next reference line. Motor remains energized for unidirectional rotation until next reference line enters light beam and produces pulsating signal. Feedback voltage obtained by comparing signal and reference voltages at servo motor alternates direction of rotation of servo motor to center reference line for next cut.

Cam Sets Temperature in Steam Iron

In the steam iron developed by Proctor Electric Co., Philadelphia, mounting the temperature control thermostat vertically at the front makes it possible to set operating temperatures for various fabrics with a lever operated cam.



VERTICAL THERMOSTAT in nose leaves center section of iron available for larger water tank and steam generator, and placing temperature controls at front of iron allows distribution of steam vents over larger area of sole plate. Direct action of cam on thermostat prevents lost motion and gives identical temperatures when setting is approached from either direction.

Workpiece is used as a cam to guide a grinding wheel spindle around the tooth form in a machine which deburrs and chamfers hypoid gear teeth.

Needles imbedded in blocks of plastic resin form fingers to grip corrugated board in a partition assembly machine.

Digital read-out is now built into an automatic electronic micrometer. See June 1956, page 153.

Stable alignment is obtained by placing cross-feed and traverse drives of an internal grinder in the plane of the grinding wheel axis. Supporting wheelhead, workhead, and dressing diamond at line of action of cutting forces avoids deflections obtained when forces are transmitted to the base by cantilever elements.

Steel backed bronze bearings replace ball bearings in a hydraulic pump for power steering systems. Old design was generator mounted and shaft driven; new design is block mounted and pulley driven.

Magnets with high dimensional stability are made in odd shapes from powdered magnetic ferrite bonded with plastic resin. This material is used where dimensional accuracy is more important than maximum magnetic properties. It has low density and can be machined with carbide tools.

The frame of a forming press is made of rolled steel without bolted or welded joints. This press forms aircraft parts by pressing the work upward against a rubber pad, which places bulk of the press below floor level.

A car with no chassis uses fiberglass reinforced plastic moldings as structural members.

Worn track links are reclaimed by welding on new metal in an automatic machine programmed by cams.

Electromagnetic clutches reverse tapping heads driven by a single unidirectional motor.

Calibrated potentiometers pre-set the workpiece surface speed of a welding positioner within 2 per cent.

Brazing alloy is pre-placed in dimples of tubular reinforcements for bicycle frame sections.

Seamless steel tubing, used in the vertical traction shaft of a crawler shovel, reduces machining time by 2¼ man hours by making a boring operation unnecessary.

Nickel-base alloy is used in spot welding fixtures for wear resistance at high temperatures, and lower heat transfer.

Ultrasonic frequencies applied to a soldering tip with a magnetostrictive transducer makes it possible to solder aluminum and stainless steel without flux, and makes surface preparation and after-cleaning unnecessary.

A die cast zinc core which melts and is drained from the mold through a relief valve is used to cast intricate passages in valves made by Char-Lynn Company, Minneapolis, Minn.

How to reduce number of relay contacts in control circuits; switching circuit algebra and tables of combinations; identifying and sketching symmetric switching networks.

Simplifying Relay Control Circuits

MAJOR SOURCE OF FAILURE in machine tool and other equipment control circuits is relay contacts. Increasing complexity of control circuits for partially or fully automatic machines multiplies number of relays and contacts and decreases equipment reliability. For maximum reliability, number of contacts should be reduced to minimum. A significant means of reducing number of contacts for networks providing closure between two points is the use of "symmetric networks"; these networks require fewer contacts than the best designed series-parallel networks, yet provide identical switching and control functions.

To obtain a symmetric network which will fulfill given conditions of a switching problem, a "switching function" describing the problem is analyzed. This switching function is an algebraic expression which identifies the various combinations of energized or deenergized relays required to obtain closed circuits between two given points as specified in the problem. These algebraic expressions use the symbolic logic of switching algebra.

Switching Algebra

There is more than one currently accepted system of switching algebra notation. However, in all systems a relay and its contacts are designated by a capital letter; there is seldom ambiguity as to the reference. If the letter designating the relay and contacts is unprimed, as at the top left in Fig. 1, it indicates that circuit is closed, through the normally-open contact, when the relay is energized. Circuit elements forming the closed path are shown in red. If the letter is primed, such as A′ at the right, the circuit is closed through the normally closed contact when the relay is *not* energized. The algebra presented here uses multiplication (*AB′* in center of Fig. 1) to indicate a series contact circuit, and plus sign (*A* + *B′* at the bottom of Fig. 1) to indicate parallel connections of contact paths. In Fig. 1 and in other switching diagrams, all contact networks are shown with the relays deenergized.

Complex series-parallel networks are combinations of the simple series and parallel networks shown in Fig. 1.

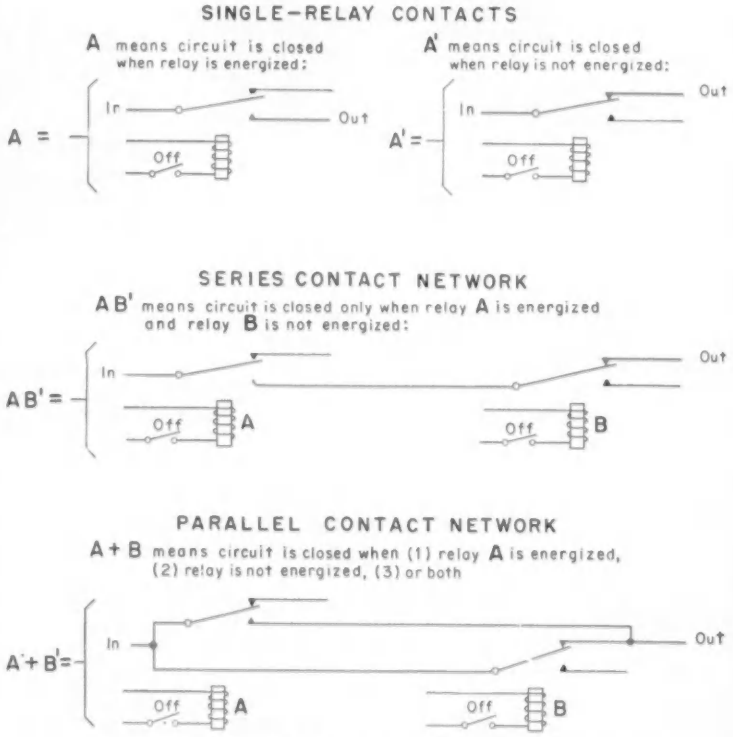

SINGLE-RELAY CONTACTS
A means circuit is closed when relay is energized:
A' means circuit is closed when relay is not energized:
A =
A' =
In
Out
Off
SERIES CONTACT NETWORK
AB' means circuit is closed only when relay A is energized and relay B is not energized:
AB' =
A
B
PARALLEL CONTACT NETWORK
A + B means circuit is closed when (1) relay A is energized, (2) relay is not energized, (3) or both
A + B' =

Fig. 1—Significance of symbols used in switching algebra. Capital letter represents both relay and contacts associated with that relay. Unprimed letter (A) means contact path is closed when that relay is energized; primed letter (A′) signifies path is closed when relay is *not* energized. Multiplication (AB′) indicates series contacts. Addition (A+B′) indicates paralleled contacts.

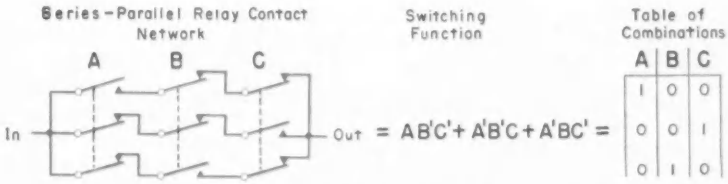


Fig. 2—At left, a series-parallel network using relays, A, B, and C. The switching function shown in the center is an algebraic expression which denotes the several, in this case three, combinations of energized and de-energized relays required to perform the multiple desired switching operations. This particular function represents combinations for the network shown. At right, the switching function is translated into a table of combinations. Letters identifying the relays are written at the top while underneath each relay a *1* indicates a relay contact is closed when the relay is energized, and a *0* indicates a relay contact is closed when the relay is not energized. Each horizontal row in the table represents a complete series-circuit path formed by contacts of the several relays under conditions specified by the *0's* or *1's* in that row.

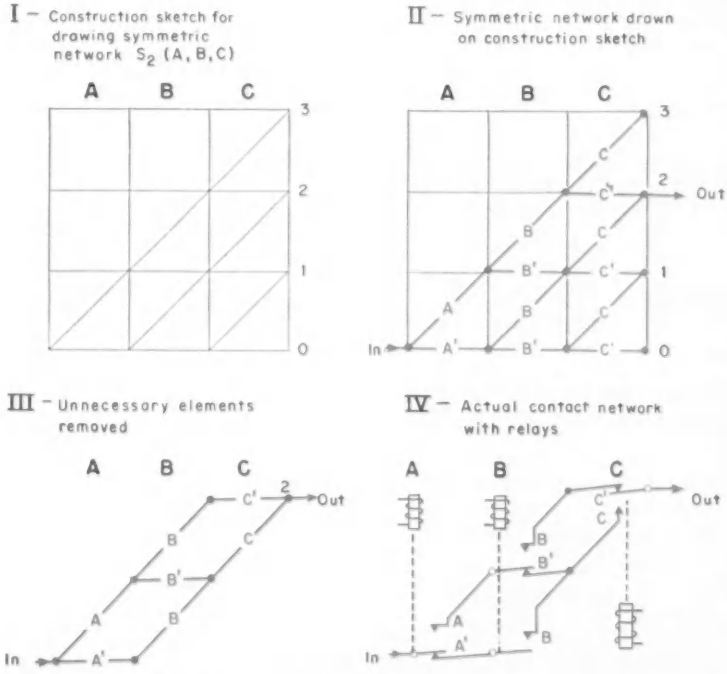


Fig. 3—How to draw a symmetric network from given symmetric switching function S_2(A,B,C), which means that using relays A, B, and C a closed circuit is formed when any two out of three are energized. In step *I* light construction lines are drawn. In step *II* the full symmetric network is drawn. The output is taken from the level denoting the number of relays operated; in this case it is *2*, but if for example, a closed circuit were desired for one or all three relays operated, levels *1* and *3* might be connected together as the *OUT* terminal. In step III unnecessary elements are removed. Step IV shows the contact network for S_2(A,B,C).

Switching algebra provides a relatively simple method of simplifying as well as describing these networks. For example, the series-parallel contact network at the left in Fig. 2 is identified by the algebraic-letter combinations or switching function of $AB'C' + A'B'C + A'BC'$. Each letter-group describes conditions required to close the row of contacts specified by that group; that is, $AB'C'$ means that the top row of contacts is closed when relay A is energized and relays *B* and *C* are de-energized; the switching functions for the succeeding two rows can be analyzed in similar manner.

Tables of combinations are used in control circuit design; they can be written from the algebraic switching function, as shown in Fig. 2, although they can also be composed from a relay contact diagram. The table defines specified combinations of energized and deenergized relays for which a circuit is closed. The letter at the head of each vertical column represents a specific relay; "1" in that column indicates a relay contact is closed when the relay is energized, a "0" means the contact is closed when the relay is not energized.

For example, in Fig. 2 the top row of network contacts, represented by the function $AB'C'$, are represented in the table by the top horizontal row: *1, 0, 0*. This means that the circuit from IN to OUT is completed when relay A is energized and relays *B* and C are not energized. The remainder of the table is derived using the same analysis.

Drawing Symmetric Switching Networks

A symmetric switching network can be identified by an expression which indicates the number of relays to be operated and which identifies the network relays by letters. For example, in the symmetric function S_2(A,B,C) the letter *S* indicates it is symmetric, *(A,B,C)* identifies the relays, and the number *2* indicates a closed circuit when any two of the three relays are energized; under all other conditions, that is if none, one, or three relays are energized, the circuit is open.

A symmetric network can be drawn according to the following procedure, using the function S_2(A,B,C) for an example. For guide lines, construct and subdivide the square as shown at the upper left of Fig. 3; draw diagonals from the lower left to the upper right along the bottom intersections. Over the center of each small square add the relay identifying letter and along the right-hand side of the large square add numbers, starting with zero at the bottom, and ending with the number corresponding to the number of relays for which the network is drawn, at the top; in this case it is 3.

Next fill in the diagonals and cross lines in the lower right-hand portion of the square as shown in color in step *II*. The symmetric circuit is now

complete. When any two relays are energized the circuit is closed between IN and OUT at level *2*.

If the original expression were $S_{2,3}$ (A,B,C), meaning the circuit is closed when any *two* or *three* relays are energized, level 2 might have been connected to level *3*, both then serving as the OUT terminal. There are unnecessary elements shown in step *II*, which are removed in step *III*. Step 4 shows the final relay contact connection required to obtain S_2 (A,B,C).

For drawing more complicated symmetric networks the procedure is an extension of that already shown. In Fig. 3 each diagonal relay element is an unprimed letter and represents a closed circuit when the relay is energized, while each lateral element is a primed letter and represents a closed circuit when the relay is not energized. This convention is used on most symmetric network drawings; however, if one of the relay symbols in the symmetric function were primed, for example S_2(A,B′,C) the primed column would cause relative positions of the primed and unprimed elements to be inverted as in Fig. 4, p. 167.

Symmetric networks with certain inherent geometrical progressions and other complex configurations, may be further simplified as described by C. E. Shannon in "A Symbolic Analysis for Relay and Switching Circuits," AIEE Transactions, 1938, Vol. 57, p 713-723.

To determine whether or not a symmetric network can be derived from any given switching function, intuitive procedures or algebraic or chart methods can be used. However, intuitive methods can be slow and provide no means of determining whether or not the minimum number of contacts has been obtained; and algebraic or chart methods may be difficult for control circuits of more than simple complexity.

New methods developed by M. P. Marcus and presented here provide a simple and rapid means for determining: (a) whether or not a symmetric network can be obtained for the desired switching combination; and (b) if so, the identification and circuit configuration of the symmetric network.

Detecting Symmetric Switching Functions

How to use tables of combinations to determine the symmetry of a switching function; how to specify the symmetric network of the function.

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TWO NEW METHODS of detecting and identifying general symmetric switching functions, with the use of a table of combinations (truth table) are presented here. These methods are simple and rapid, regardless of the number of variables involved. A "General Method" leads to a determination of symmetry or lack of symmetry under all possible conditions. A "Contingent Method" has the advantages of being slightly simpler than the General Method and in the majority of cases of being faster to perform. However, in one case it will not yield a solution, and the General Method will have to be employed.

For both methods the switching function to be checked for symmetry is written as a table of combinations, as shown at top in Fig. 1. At the head of each vertical column the denoted variable is written unprimed. The table should be checked to assure that no horizontal row combination occurs more than once; any duplication must be eliminated.

General Method

To use the General Method, first obtain the arithmetic sum of each horizontal row in the table and write it to the right of the row. Check all row sums for sufficient occurence as follows: if *n* represents the number of variables (columns), and *r* represents a row sum, then the number of times that row sum should occur is:

$$\frac{n!}{r!\,(n-r)!}$$

The required horizontal row sum occurrence for a maximum of eight variables is given in Table I; this table is an adaptation of Pascal's Triangle and may be extended to include as many variables as desired.

1. If all row sums occur the required number of times, the function is symmetric, as shown in Fig. 1.

2. If any row sum does not occur the required number of times, select any one row sum of insufficient occurrence except $r = n/2$. (A row sum equal to one-half the number of variables can, of course, occur only if the number of variables is even.) Considering only the horizontal rows totaling this sum, obtain a partial arithmetic sum of each vertical column. In Fig. 2 this is done using the horizontal rows totaling 2.

(a) If more than two different partial column sums occur, the function is not symmetric.

(b) If two and only two different partial column sums occur, as at the lower left of Fig. 2, select either one of these sums (preferably the one of lesser occurrence) and in the original table double-negate all columns which contain this partial sum. To double-negate a column: (1) prime the variable at the head of the column, and (2) change all 1's to 0's and all 0's to 1's. A double-negation leaves the meaning of the column unaltered.

Obtain new horizontal row sums and check for sufficient occurrence. If

all row sums occur the required number of times, the function is symmetric; otherwise the function is not symmetric.

(c) If the number of variables is odd and all partial column sums are identical, the function is not symmetric.

If the number of variables is even and all partial column sums are identical or if the only horizontal row sum of insufficient occurrence is equal to one-half the number of variables so that no row sum selection may be made, select at random and double-negate any one vertical column, and obtain new horizontal row sums. All new row sums will not occur the required number of times and step 2 is repeated once.

If, on this repetition of step 2, all partial column sums are identical, the function is not symmetric.

Contingent Method

To use the Contingent Method, first obtain the arithmetic sum of each vertical column in the table of combinations and write it at the foot of the column.

1. If more than two different column sums occur, the function is not symmetric.

2. If two and only two different column sums occur, obtain the total of

Symetric switching functions lead to relay contact networks which are much more economical of elements than the best series parallel circuit. A symmetric function may be defined as one whose variables may be interchanged without altering the function.

The "*m*-out-of-*n*" type of network, a network which is closed when any three (m) out of five (n) relays are operated, is related to symmetric functions having variables of symmetry which are either all unprimed or all primed. All other symmetric functions have some but not all of the variables of symmetry primed. Since there are 2^n ways of priming n variables of symmetry, and only two of these result in the variables being either all unprimed or all primed, there are 2^n-2 ways which are not associated with the "*m*-out-of-*n*" type of circuit. Therefore, the "*m*-out-of-*n*" networks account for only a small portion of the symmetric functions. Possibly because of the difficulty in detecting and identifying symmetric functions other than the all unprimed or all primed type, treatment of them has been omitted from almost all of the work in this field.

Table I—Required Occurrence of Horizontal-Row Sum for Symmetry

Row Sum, r	Number of Variables, n							
	1	2	3	4	5	6	7	8
0	1	1	1	1	1	1	1	1
1	1	2	3	4	5	6	7	8
2		1	3	6	10	15	21	28
3			1	4	10	20	35	56
4				1	5	15	35	70
5	Required Occurrence of Row Sum = $n!/r!(n-r)!$				1	6	21	56
6						1	7	28
7							1	8
8								1

$$A\,B'C + A'\,B'C + A'\,BC' = S_1\,(A,B,C)$$

A	B	C	
1	0	0	1
0	0	1	1
0	1	0	1

n (number of variables) = 3 (A, B, C)

r (row sum) = 1

Required occurrence of $1 = \frac{n!}{r!(n-r)!} = \frac{3!}{1!(2)!} = \frac{3\cdot 2\cdot 1}{1(2\cdot 1)} = 3$

$$ABC' + ABC + AB'C + A'BC = S_{2,3}\,(A,B,C)$$

A	B	C	
1	1	0	2
1	1	1	3
1	0	1	2
0	1	1	2

$n = 3, r_1 = 2$

Required occurrence of $2 = \frac{3!}{2!1!} = 3$

$n = 3, r_2 = 3$

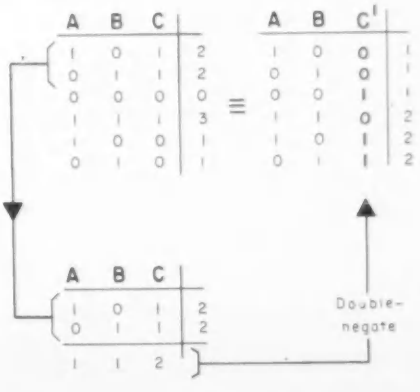
Required occurrence of $3 = \frac{3!}{3!0!} = 1$

(Note: $0! = 1$)

Fig. 1—Using the General Method to detect the symmetry of switching functions. Horizontal row sums occur required number of times, as indicated by calculations, therefore both examples are symmetric. The symmetric function from which the network is sketched is identified from the letters at the top of the table of combinations and the horizontal row at the right of the table.

Fig. 2—Determining symmetry of switching function when row sums do not occur required number of times. Procedural steps are described in text in step 2 of General Method.

$$A\,B'C + A'BC + A'B'C + ABC + AB'C' + A'BC' = S_{1,2}\,(A,B,C')$$



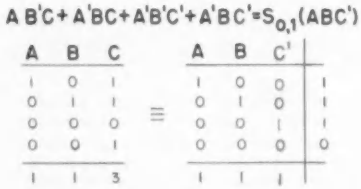


Fig. 3—Using Contingent Method to determine symmetry of switching function. This function is found to be symmetric in $S_{0,1}(ABC')$.

these two sums and compare it with the number of horizontal rows in the table.

(a) If the total of the two different column sums is not equal to the number of horizontal rows in the table, the function is not symmetric.

(b) If the total of the two different column sums is equal to the number of horizontal rows in the table, select either one of these sums (preferably the one of lesser occurrence), and double-negate all columns totaling the selected sum. If the selected column sums are corrected to represent the new total for the double-negated columns, all column sums will now be found to be identical.

Obtain the horizontal row sums and check for sufficient ocurrence, as shown in Fig. 3. If all row sums occur the required number of times, the function is symmetric; otherwise, the function is not symmetric.

3. If all column sums are identical, compare them with one-half the number of horizontal rows in the table.

(a) If the column sums are not equal to one-half the number of horizontal rows in the table, obtain the horizontal row sums and check for sufficient occurrence. If all row sums occur the required number of times, the function is symmetric; otherwise, the function is not symmetric.

(b) If the column sums are equal to one-half the number of horizontal rows in the table, the General Method must be employed.

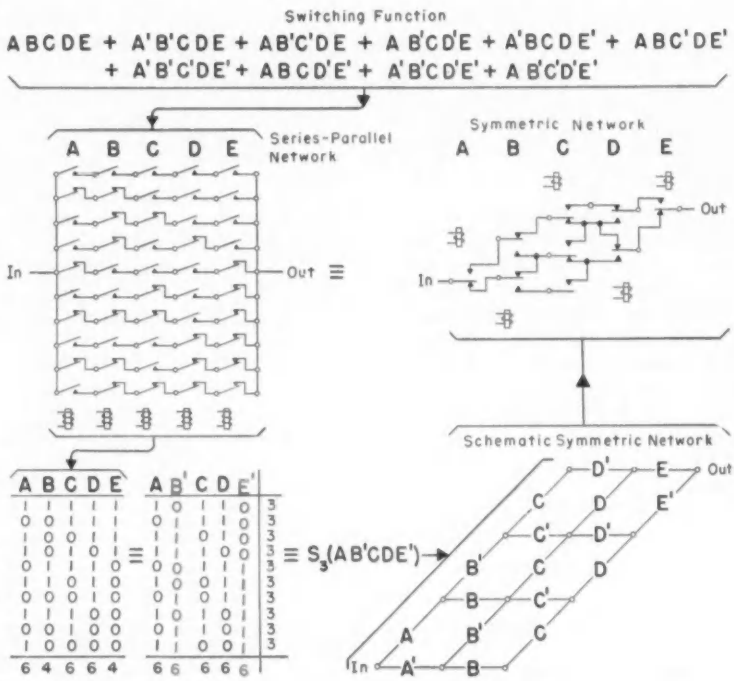


Fig. 4—Complex switching function evaluated using the Contingent Method. Original function is represented in unsimplified form by complex series-parallel network shown, and also by table of combinations at lower left-hand of illustration. The function is identified as being symmetric in $S_3(A,B,C,D,E')$, and schematic of equivalent symmetric network is shown at lower right-hand corner. Directly above is contact network representing same, providing same switching functions as complex series-parallel network at left; however, in practice series-parallel network would have been somewhat simplified by either intuitive or cut-and-try-methods, but would not have approached the symmetric network in simplicity.

Mechanical Properties of Large Aluminum Alloy Forgings

Results of tensile and bend tests on specimens in the T6 condition from 12 x 12 x 24 in. hand forgings of 7075 (75S) and 2014 (14S) aluminum alloy have been presented by James A. Miller and Alfred L. Albert, National Bureau of Standards, in NACA Technical Note 3729. Properties are given for specimens from various locations within the forgings as well as for both longitudinal and transverse specimens.

Tensile and bend tests on material in the T6 condition which was cut from 12 x 12 x 24 in. hand forgings of 7075 and 2014 aluminum alloy lead to the following conclusions:

Stress and strain at failure varies with the location and the direction of the specimen in the forging, but there is no consistent relation between the values for specimens parallel to the direction of the length of the forging and the values for specimens in either transverse direction.

Biaxial tensile stress conditions cause fracture to occur at a much lower strain than for bend specimens in which the critical stresses are uniaxial.

The ratio of modulus of rupture to tensile strength for low elongation material increases with increase in strain at the beginning of failure.

Tensile and Comprehensive Tests To 1 Per Cent Strain

Test	Direction	Yield strength, psi (offset, 0.2 pct)	Initial modulus of elasticity psi
7075-T6:			
Tensile	Long.	66,300	10,300,000
Compressive	Long.	69,600	10,300,000
Tensile	Trans.	63,700	10,200,000
Compressive	Trans.	68,000	10,200,000
2014-T6:			
Tensile	Long.	58,300	10,600,000
Compressive	Long.	59,700	10,600,000
Tensile	Trans.	57,600	10,600,000
Compressive	Trans.	60,200	10,600,000

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Plastics for high-impact applications
Mechanical, electrical and optical properties
Cost data for 28 compositions

HOW TO CHOOSE

TOUGH, RIGID

THERMOPLASTICS

R. K. MULTER and H. H. IRVIN
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PROPERTIES OF THERMOPLASTICS useful in product design are low specific gravity, chemical inertness, color potential, good electrical properties, easy formability and low raw material cost. These materials have suffered, however, from a lack of toughness and ductility. To reduce cracking of finished parts by impact or bending, a number of tough thermoplastic materials have been developed which exhibit higher impact strength and elongation without major sacrifice of rigidity or surface hardness.

A tough thermoplastic is arbitrarily defined here as having a notched Izod impact strength of at least 1.0 ft-lb/in, based on experience that plastics tougher than 1 – 3 ft-lb/in. resist shattering in most applications. A rigid thermoplastic is defined as having a tensile modulus of at least 100,000 psi; this eliminates the high pressure polyethylenes, elastomeric vinyls, and other rubbery materials.

Although the accompanying chart uses customary nomenclature for classifying materials according to chemical origin, such classification is for indexing purposes only. For the designer, chemical type has little fundamental utility. Names such as "vinyl" or "modified styrene" cover materials which vary widely in their range of properties; tough or brittle, rigid or flexible, low or high cost. Such terms used without reference to trade name and number are no more specific than "ferrous", "wood" or "paint". Manufacturers listed are original resin suppliers.

The chart is designed to simplify the selection of a material with the desired balance of properties for a particular use and is arranged for preliminary screening rather than for detailed design data. With a wide variety of thermoplastics available, this initial weeding is the most difficult design task. For example, should exceptional stiffness and moderate toughness be required, a glass-filled styrene is indicated. If toughness and ductility are of primary importance, with stiffness and hardness distinctly secondary, one of the low pressure ethylenes would be suitable. Should this group prove too soft, a shift to an acrylonitrile-butadiene-styrene copolymer will improve hardness.

Material characteristics are in four categories: mechanical, physical, electrical and general. Each property has three ranges shown in descending order of design value: high impact strength, low volume cost, high hardness and so on. Property data are taken at 75 F except where noted.

Impact strength and tensile elongation are the prime considerations in high-impact plastic design. Although high Izod strength and high elongation often occur together, they should be considered different properties. Izod strength indicates resistance to breakage by dropping or other impact; elongation shows resistance to cracking during crushing, twisting, or other extreme, but slow deformation. Ordinary rigid thermoplastics not covered in the chart have impact strengths below 1 ft-lb/in. and elongations under 5 per cent.

Stiffness indicates resistance to deflection. As such, it reflects both the elastic modulus and the physical distribution of the material in the part being designed. The

Many tough, rigid thermoplastics may be brilliantly colored as illustrated by these parts of Marbond "Cycolac" resin. See reverse side for table of properties. Red automobile timing light gun, center, resists shattering on garage floor.

modulus, together with impact strength, determines minimum section thicknesses. With these established, the volume of material needed can be computed.

Hardness in thermoplastics is used to indicate resistance to surface marking. A plastic with a Rockwell hardness below approximately 100 R can be marked by finger contact.

Tensile strength has surprisingly little utility in thermoplastic design. Most thermoplastics exhibit creep at low loads. This deformation behavior in thermoplastics is highly influenced by temperature and rate of loading. Consequently, tensile strength is a poor index of proper design loading. As a general rule, static service loads should be kept below one-fourth published tensile strength data.

Optical properties are important in decorative products. The unpigmented clarity tells whether a plastic can be used for glazing or for light diffusers. Some plastics, though clear, are yellow; others, though white, are nearly opaque. Clarity and color may vary between brands and grades of similar plastics. Ability to take strong coloring depends on limitations in the resins, coloring agents, and manufacturer's techniques. Polyethylenes, for instance, can only carry a small amount of pigment, and nylons can hardly be colored at all. Conversely, several plastics which are neither transparent nor white can be made in many bright colors. Gloss varies widely among these materials, but depends in part on finishing techniques.

Service temperature limits are based on practical experience rather than a single test method. The upper temperatures shown are the highest service temperatures which a product could withstand in normal use before collapsing of its own weight or seriously warping. Many high-impact plastics become brittle as temperatures are lowered. The low-temperature limits are those at which the notched Izod toughness falls below 1 ft-lb/in.

Flammability ratings show that all of these plastics are relatively slow-burning; some are non-flammable or self-extinguishing. While none present the ignition hazard asosciated with the old cellulose nitrates, some will produce toxic fumes if held in a flame. This must be considered in applications where legal requirements are a factor. Among those which may generate poisonous vapors are the fluorocarbons, cellulosics, and vinyl chlorides.

Thermal properties of these plastics are quite similar. In comparison with metals, plastics are all good insulators with higher expansion coefficients and higher specific heats. The range of these properties is given in the following table.

Thermal Properties of Tough, Rigid Thermoplastics

Thermal Conductivity, Btu/hr/sq ft/deg F per in.	0.006 – 0.040
Coefficient of Expansion, per deg F	0.00002 – 0.00012
Specific Heat, Btu/lb/deg F	0.2 – 0.4

Water absorption depends on the chemical composition of the resin. Materials such as polyethylene and fluorocarbons do not attract water. Cellulosics and nylon type polyamides absorb appreciable quantities of water which adversely affects dimensional stability. Between

these two types there are the styrene and vinyl chloride plastics; polymers in this group are generally unaffected by moisture, although their tendency to absorb water varies with composition. Water absorption data also indicates permeability to water vapor and resistance to dilute aqueous chemicals. With prolonged outdoor exposure, most of these plastics become slightly discolored and display varying degrees of surface embrittlement or crazing, depending on pigmentation and conditions of exposure.

Chemical resistance is difficult to evaluate precisely. Many published data are unreliable because tests to determine the effect of chemicals on physical properties are run after, not during immersion in the chemical under investigation. Stress corrosion effects are prevalent and account for many service failures. The fluorocarbons resist most chemicals; polyethylene resists many when temperatures are below 150-200 F. Most of the remaining types of thermoplastic materials will be attacked by strong oxidizing acids and by certain organic solvents. Simulated service tests are advisable before published chemical resistance data is accepted.

Electrical properties of high impact plastics are quite similar. The materials are good electrical insulators, with characteristics almost independent of frequency.

Weight is expressed as cubic inches per pound rather than as specific gravity because its chief use is in calculating how much volume can be expected from a dollar's worth of materials; manufacturer's prices are quoted by the pound. The cost in cents per cubic inch is useful when comparing the price of a proposed part using several different plastics. The tabulated figures are based on the largest normally quoted lot sizes in the least expensive colors.

Ease of fabrication depends largely on the knowledge, experience, and equipment of each processor, as well as on the design of the plastic part. Minor modifications in the shape of an injection molded part, for instance, may greatly lessen mold costs, reduce required weight, or simplify the molding operation itself.

All the tough, rigid thermoplastics except the fluorocarbons can be injection molded. Some require small or easily filled dies. Nylon and polyethylene need more refined techniques and are often molded by specialists. Polyvinyl chlorides are also difficult to mold, primarily because of their tendency to decompose at elevated temperatures. Sheet material for subsequent post-forming can be readily produced from all of these materials, either by calendering or extruding. All can be extruded into various shapes.

Machining is simplest with the tough, stiff materials; most can be handled by a good machinist if cutting temperatures are kept low. Thermal-welding, solvent-welding, and adhesive bonding are possible with most of the high-impact thermoplastics. Their high ductility permits good use of screws, rivets, staples and other mechanical fasteners.

EDITOR'S NOTE

Previous articles published in *Product Engineering* on plastics as load bearing materials include the following:

"Plastics for Structural Uses," June 1956 page 167; a staff report evaluating recent developments in plastics and processing techniques which permit higher load design.

"Plastic Springs," June 1956 page 183; torsional elastic properties of various resins, performance of glass-reinforced epoxy springs.

"Resins for Reinforced Plastics," May 1956 page 199; five major classes of resins evaluated. Properties, processing characteristics, costs, advantages and limitations.

"Kralastics – A New Thermoplastic Material," November 1955 page 171; detailed data on a recently developed tough, rigid thermoplastic.

"Fluorocarbon Plastics Today," October 1954 page 168; comparison of rigid and non-rigid thermoplastic fluorocarbons.

Two articles on tough, non-rigid plastics are: "Flexible Epoxy Plastics", September 1954 page 154 and "Polyethylene's Potential in Large Plastic Structures," April 1954 page 146.

"Sintered Nylon Plastics," November 1954 page 150; sintered nylon compared to powdered metals and injection molded nylon. New method broadens application of nylon for intermittent service or where lubrication is difficult and load-speed characteristics are low.

"Plastics for Mechanical Components," 1956 Annual Digest, page C22 compares nylon to Teflon, both filled and unfilled, for machine parts; wear data and temperature limits.

Comparison of plastics performance in corrosive media is simplified by "Indices for Chemical Resistant Plastics," 1955 Annual Digest, page C7.

A useful tabulation of properties for rigid thermoplastic and thermosetting resins will be found in 1953 Annual Digest, page C31: "Properties of 17 Popular Modern Rigid Plastics."

TURN PAGE for selection chart: 28 plastics classified by chemical type, trade name and manufacturer; 17 characteristics divided in 3 ranges for each plastic simplifies selection of chemical type for high-impact.

Characteristics of Tough, Rigid Thermoplastics

MATERIAL			Toughness *Notched Izod, ft-lb/in.*			Stiffness *Modulus, psi*		
Chemical Type	Trade Name	Manufacturer	Over 4	1 to 4	Under 1	Over 400,000	200,000 to 400,000	
Acrylonitrile-butadiene-styrene copolymer	Cycolac	Marbon Chemical Co.	✓				✓	
Acrylonitrile-butadiene-styrene rubber-resin blends	Kralastic	Naugatuck Chemical Co.	✓				✓	
Cellulose acetate	Celanese acetate	Celanese Corp. of America		✓			✓	
	Tenite acetate	Eastman Chemical Products		✓			✓	
	Hercocel A	Hercules Powder Co.		✓			✓	
Cellulose acetate butyrate	Tenite Butyrate	Eastman Chemical Products		✓			✓	
Cellulose propionate	Forticel	Celanese Corp. of America		✓				✓
Ethyl cellulose	Ethocel	Dow Chemical Co.		✓			✓	
	Hercocel E	Hercules Powder Co.		✓			✓	
Ethylene (low pressure)	Grex	W. R. Grace Co.	✓					✓
	Hi-fax	Hercules Powder Co.	✓					✓
	Super Dylan	Koppers Co.	✓					✓
	Marlex 50	Phillips Chemical Co.	✓					✓
Fluorochlorocarbon	Fluorothene	Bakelite Co.		✓			✓	
	Kel-F	M. W. Kellog Co.		✓			✓	
Nylon	Plaskon Nylon	Allied Chemical and Dye		✓			✓	
	Zytel	E. I. du Pont		✓			✓	
Styrene, glass-filled	Fiberfil	Fiberfil Corp.		✓		✓		
	Fibertuff	Koppers Co.		✓		✓		
Styrene, modified	2155	Bakelite Co.	✓				✓	
	Styron	Dow Chemical Co.	✓				✓	
	Plio-Tuf	Goodyear Tire & Rubber Co.	✓				✓	
	Dylene	Koppers Co.	✓				✓	
	Lustrex	Monsanto Chemical Co.	✓				✓	
Vinyl chloride copolymers and blends	Exon	Firestone Plastics Co.	✓				✓	
	Geon	B. F. Goodrich Co.	✓				✓	
	Marvinol	Naugatuck Chemical Co.	✓				✓	

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													Softening			*Embrittling*					
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														Clarity			*Colors*					
0.001 to 0.010	Over 0.010	Under 3	3 to 6	Over 6	Over 600	400 to 600	Under 400	Over 10^{14}	10^{13} to 10^{14}	Under 10^{13}	Under 0.1	0.1 to 0.4	Over 0.4	Colorless, transparent	Colored or translucent	Opaque	Many	Limited	None	Under 1.5	1.5 to 3.0	3.0 to 9.0
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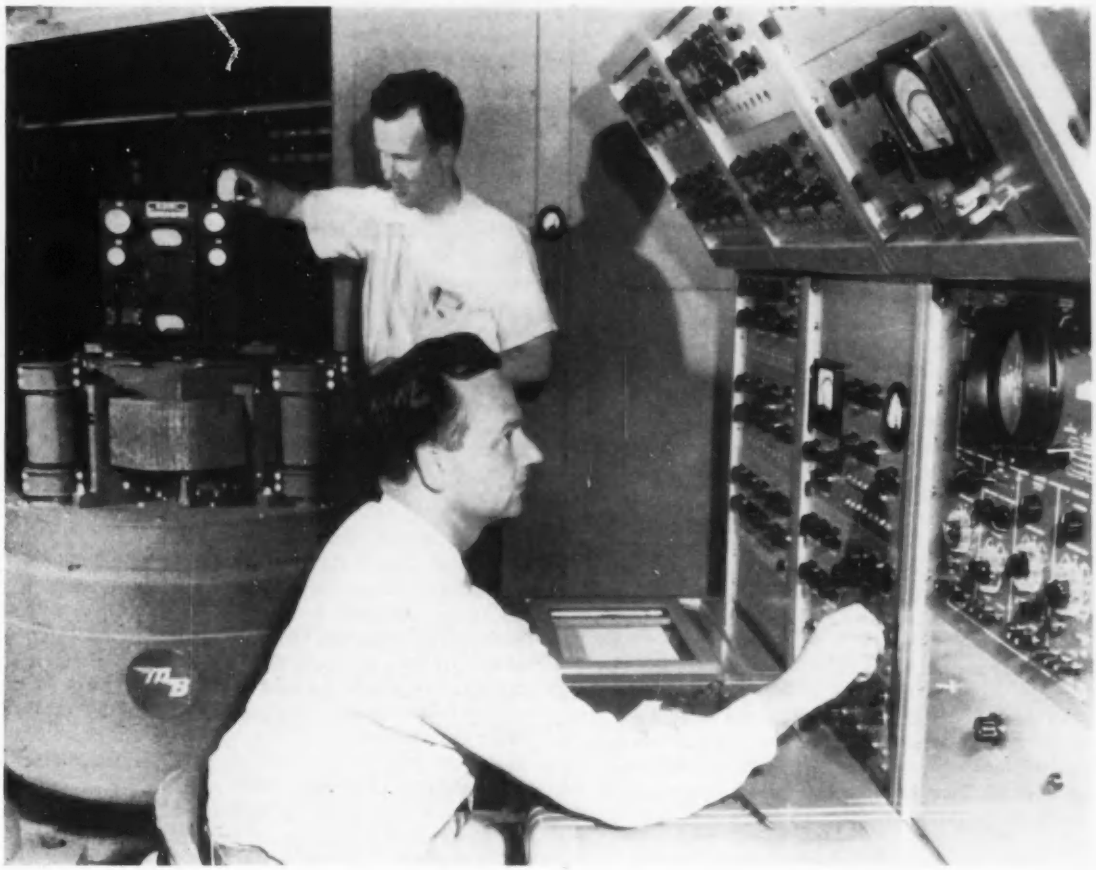


RANDOM MOTION

Characteristics of random motion; an electrical analogy and methods of calculation; response of systems to random motion; simulation of environment and prediction of component reliability.

G. B. BOOTH
Chief Project Engineer, MB Manufacturing Co.

RANDOM MOTION is a common occurrence in nature. Yet in the field of technology, there have been persistent efforts to simplify random disturbances by acknowledging only the obvious sinusoidal vibrations. This simplification has yielded useful results and therefore has formed the basis for reliability design criteria. But increased speed in aircraft and machinery has increased the frequency of component failure—with random vibrations now known to be a major cause.

Thus a better understanding of random motion is required. If the motion can be specified in terms of definite numbers, the motion in turn can be reproduced under laboratory conditions. Components which survive the test can be expected to operate reliably in the actual environment.

The most obvious characteristic of random motion is that it is non-periodic. The acceleration of periodic motion,

such as sinusoidal, is determined completely by motion in the past. This is not true for random motion. A knowledge of the past history of random motion is adequate to predict the relative probability of occurrence of various accelerations, but insufficient to predict the precise magnitude at a specific instant.

Random motions are not erratic in the common sense, but follow a very definite law. These motions are the result of a very large number of events occurring by chance. In a missile or automobile engine they are caused by the independent actions of the gas molecules in the exhaust and around the structure. Cumulative effect of such actions is a motion that has specific characteristics and may be described by a normal probability law. Occurrence of certain types of motions is highly probable–and occurrence of others very improbable. As an example, there is little chance that three complete cycles of a sinusoidal motion will occur, but a very high probability that the motion will reverse its direction.

Magnitude characteristics of all random motions are governed by the same law and may be identically described. But the intervals between pulses are not at all similar and may vary from one extreme in which an acceleration-time curve looks like ragged grass to another in which the acceleration-time curve looks like a sine wave of slowly changing amplitude.

Typical motion which may occur in a random environment is shown in Fig. 1, in which instantaneous acceleration is plotted against time. Both the magnitude of the peaks and the period of time between zero acceleration varies irregularly. Acceleration is at a relatively low level most of the time, and only rarely reaches high peaks.

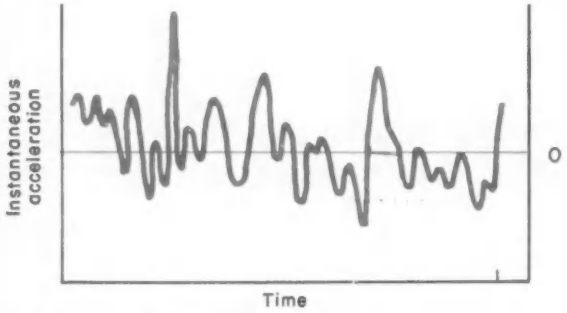


Fig. 1—Acceleration-time curve of typical random motion. Both the magnitude of the acceleration peaks and period of time between zero acceleration varies irregularly.

Although this motion appears completely erratic, its long term or average characteristics can be precisely stated. The motion, and the sound which usually accompanies it, has the characteristics of noise–but it is a refined, high quality type of noise.

Acceleration Density

The curve in Fig. 1 is an inconvenient way to describe random motion because the acceleration at any instant cannot be stated by a simple function. However, it can be shown mathematically that any random motion can be described by an infinite series of over-lapping sinusoidal curves, each curve cycling at its own frequency and amplitude as shown in Fig. 2. This approach leads to a new property of vibratory motion called the "acceleration density" which gives a more concise picture of random motion when plotted as a function of frequency as in Fig. 3.

The equation for the acceleration density is

$$G = \underset{B \to 0}{\text{Limit}} \frac{a^2}{B} \qquad (1)$$

where:

G is the acceleration density in units of the square of the acceleration caused by gravity divided by frequency in cycles per sec., g^2/cps; a is the root-mean-square (rms) average of the random accelerations; B is the range of frequency under consideration, such as: 30 to 300 cps. It is called the "band width." The value for a can be obtained directly by measuring the environment or calculated from an acceleration-time curve, such as shown in Fig. 1, by squaring the instantaneous accelerations, computing the average or mean of the squared values, and then taking the square root of the average. For example, the rms average of one and seven is not four but five as shown by the following calculations.

$$1^2 + 7^2 = 1 + 49 = 50$$
$$50/2 = 25$$
$$\sqrt{25} = 5$$

Acceleration density-frequency curves are now being used throughout the guided missile program to predict the reliability of a component subjected to random motion. Since damage is primarily caused by the magnitude of the acceleration density in the frequency bands near the resonances of the component, the probability of damage

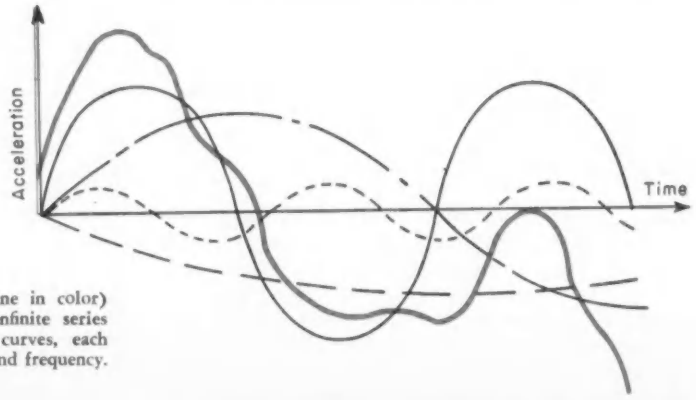


Fig. 2—Random motion (line in color) can be considered as an infinite series of overlapping sinusoidal curves, each with a different magnitude and frequency.

can be estimated and corrective measures taken.

If the acceleration density-frequency characteristic does not vary with time, the random motion is called stationary or steady state. A graph of acceleration density as a function of frequency completely defines a steady state random motion.

The term "acceleration density" is synonymous to complete descriptive titles such as "mean square acceleration spectral density," or "mean square acceleration per cycle." A graph of the acceleration density as a function of frequency is sometimes called a "mean square acceleration density spectrum." Since these long names are cumbersome, various short names have appeared. Acceleration density has also been called "power density," analogous to the power which is dissipated in an electrical resistor when the acceleration is represented by voltage across the resistor.

Calculations for the rms acceleration of random motion are similar to that of sinusoidal motion—but for one difference. The rms acceleration of sinusoidal motion is unaffected by bandwidth as long as all of the frequency components of the motion are within the band. The problem is more complex in random motion because the rms acceleration is a function of the frequency band under consideration. Higher values of rms acceleration are obtained as the band is widened, lower values as the band is narrowed.

Measuring the Environment

To measure a structure subjected to random motion a transducer is attached to the structure to convert the instantaneous acceleration to a proportional voltage. The voltage is then filtered to a bandwidth B and the reading of the meter calibrated in rms g is used to calculate the acceleration density.

To measure random motion of an actual physical structure, instruments arranged in the order shown in Fig. 4 are used. The block at left represents the environment. Since in most cases the motional environment of a component will be the motion of the structure of an airframe, the block is also labeled "structure." The structure is activated to move sinusoidally so as to calibrate the instrumentation and then to move randomly with an acceleration density of magnitude G to investigate the effect of random motion.

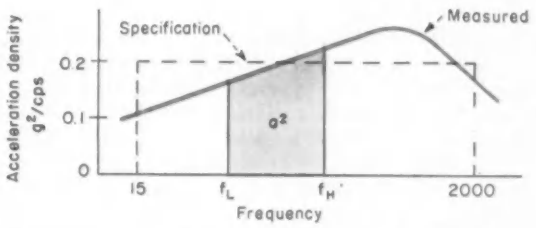


Fig. 3—A more concise and practical way of representing the random motion curve in Fig. 1 is by an acceleration density-frequency curve. Solid line represents the actual motion; dashed line a typical test specification.

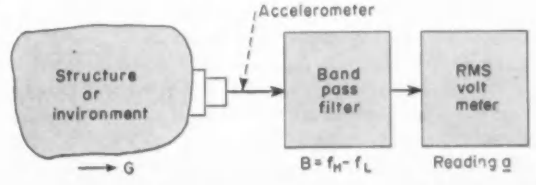


Fig. 4—Basic instruments necessary to measure the acceleration density of a structure or environment which is moving randomly.

An accelerometer, attached to the structure, produces a voltage proportional to the acceleration of the structure. The voltage is then applied to a bandpass filter which permits only the frequencies within the bandwidth B to pass through. Thus the output voltage of the filter will equal the input voltage if all the frequency components of the input are within the band width (between a low cutoff frequency f_L *and a high cutoff frequency* f_H). Other frequencies are not reproduced at the output.

The rms voltmeter reads the output voltage of the bandpass filter with a reading of magnitude a. Such a meter automatically performs the root-mean-square operation on the voltage waveform. Sensitivity of the meter is adjusted until the reading a is equal to the acceleration of the structure in rms g.

Physical meaning of the concept of acceleration density may be obtained by relating the magnitude G of the acceleration density, the reading a of the rms voltmeter and the bandwidth B of the filter to analogous factors in Eq (1).

To calibrate the system in terms of the the more familiar sinusoidal units, the structure is excited with a sinusoidal acceleration of one g rms which is 1.41 g in peak acceleration units used for sinusoidal accelerations. If frequency of such motion is within the bandwidth, the rms voltmeter can be calibrated to read the value 1. This makes the dial of the voltmeter read directly the rms value of the acceleration of the environment. As the frequency of the sinusoidal motion is varied with the amplitude fixed at 1 g rms, the meter will continue to read 1 as long as the frequency is within the bandwidth. But it will drop to zero whenever the frequency of the sinusoidal motion becomes lower than f_L or higher than f_H.

If the structure is now allowed to move randomly, the accelerometer will produce a random voltage. Frequency components of this voltage within the bandwidth will be applied to the voltmeter and reading a of the voltmeter will be the random acceleration of the structure in rms g for the frequency band.

Decreasing the bandwidth of the bandpass filter decreases the voltmeter reading. This indicates that the rms random acceleration for a narrow band of frequency is less than for a wide band. As the bandwidth is reduced, the meter indication not only decreases, but decreases smoothly, which indicates that the acceleration of the environment is distributed over the frequency spectrum rather than concentrated at discrete frequencies.

As the bandwidth is reduced to very narrow values, the indicator on the meter will start to fluctuate slowly about a mean value, and the smaller the bandwidth the slower the fluctuations. Although the fluctuations are not periodic, the frequency of fluctuation is approximately the bandwidth of the filter in cps.

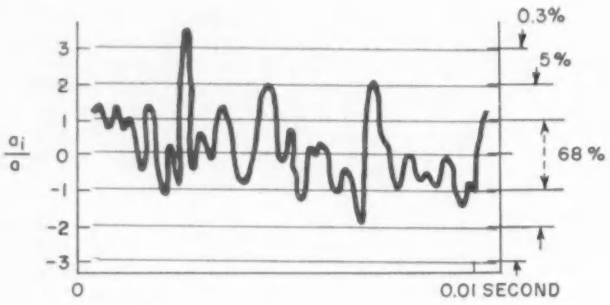
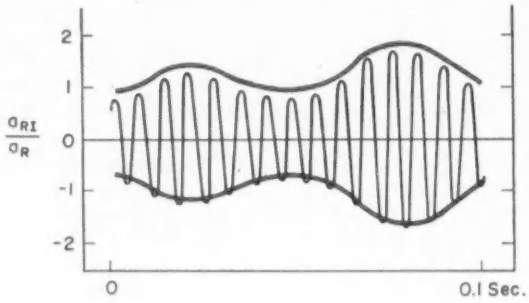


Fig. 5—Probability of instantaneous accelerations occurring in random motion. For example: 68 per cent of the time acceleration peak will be within $a_i/a = \pm 1$.

Fig. 6—Narrow band random motion. The low and high frequencies are screened out from the curve in Fig. 5 leaving a curve resembling sinusoidal motion with a varying amplitude and phase. However, probability of occurrance of specific accelerations is approximately the same.



If the bandwidth is reduced by successive factors of four, the rms random acceleration will drop by factors of approximately two. This relationship becomes more exact as the bandwidth is reduced and, for narrow bandwidths, the square of an rms random acceleration is proportional to the bandwidth, or $a^2 \propto B$. As B decreases, the quantity a^2/B approaches a constant value called the acceleration density G. This result is expressed by Eq (1).

An acceleration density measured in a typical random environment is shown by the solid line in Fig. 3. In most environments, the acceleration density is not constant, but a function of frequency. In any airframe both the level and the shape of the acceleration density spectrum vary from point to point within the structure.

Dashed line in Fig. 3 is a typical test specification. The shape of this specification has been chosen because the environment it represents is simple to reproduce in the laboratory and is a logical compromise between the many measured curves. An environment with a constant acceleration density as a function of frequency is called a white or flat random motion spectrum and designated as G_o. For a flat spectrum the limiting process of Eq (1) is unnecessary; the acceleration density is independent of bandwidth and the equation reduces to

$$G_O = \frac{a^2}{B} \tag{1a}$$

Knowing that the acceleration density is a function of frequency, the rms acceleration for a frequency band between f_L and f_H can be calculated from the following equation:

$$a^2 = \int_{f_L}^{f_H} G df \tag{2}$$

Eq (2) defines the rms acceleration as the square root of the area under the solid curve in Fig. 3 between frequencies f_L and f_H, as indicated by the cross-hatched area. As the bandwidth of the instrumentation is increased, the observed rms acceleration will continue to increase until the complete area under the acceleration density curve is included.

For the white random vibration case, in which the acceleration density is independent of frequency over this frequency band, Eq (2) can be simplified to:

$$a = \sqrt{BG_o} \tag{3}$$

in units of g rms. This simplification is commonly used for random vibration testing.

As an example, a random motion test specification may call for a constant acceleration density of 0.2 g^2/cps over the bandwidth from 15 cps to 2015 cps. (The value 0.2 g^2/cps is frequently used throughout the aircraft and missile industry as a test specification.)

From Eq (3):

$$a = \sqrt{(2015 - 15)\,(0.2)} = 20g \text{ rms}$$

Now that the rms acceleration has been defined the vertical axis in Fig. 1 can be calibrated. The curve in Fig. 5 is identical to the curve of Fig. 1 except that the vertical axis has been marked off in units of the ratio of instantaneous acceleration a_i to rms random acceleration a as calculated from Eq (2). Although the precise acceleration which will occur at any future instant cannot be calculated, the probability of that acceleration occurring can be stated in terms of multiples of the rms random acceleration for all random motions. Most of the time the instantaneous acceleration will be low, in fact 68 per cent of the time it will be between the rms values of plus and minus one. The magnitude of the instantaneous acceleration will exceed twice the rms value about 5 per cent of the time and three times the rms value about 0.3 per cent of the time. If the curve of Fig. 5 represents the example above, the rms value between plus and minus one will be 20 g and one peak will exceed 60 g.

The curve in Fig. 5 represents a wide band acceleration. In a narrow band, the probability relationships are the same, and if the bandwidth is sufficiently narrow, for example less than 20 per cent of the center frequency of the band, the curve will begin to resemble sinusoidal motion. The sinusoidal motion will have a frequency about the same as the center frequency of the narrow band, but with a constantly varying amplitude and phase. The curve of Fig. 6 is a narrow band random motion with the low and high frequencies screened out.

The Response

What happens to a specimen subjected to random motion? Consider first a simple system subjected to a sinusoidal excitation. The system (A) in Fig. 7 represents either a single degree of freedom system or the normal mode of a more complex system. It contains a mass, spring force and damping force. The environment which excites the motion is represented by the block labeled "structure."

Response a_{sR} of the system to sinusoidal excitation a_s is shown in (B). If the frequency of excitation is low, the spring will be essentially a rigid connector, and the mass will move with the excitation. At very high frequencies, the inertia of the mass will be large and its motion almost zero. At an intermediate resonant frequency f_n, motion of the mass may build up to a magnitude considerably greater than that of the excitation.

Maximum ratio a_{sR}/a_s of motion of the mass to the structure for sinusoidal excitations is called the peak magnification factor, or Q, of the resonance. Factor Q is also equal to the reciprocal of twice the ratio of actual damping to critical damping for this normal mode. An estimate of the magnitude of Q for a resonance can be made by dividing resonant frequency by the difference between the frequencies at 70 per cent of response Q at resonance. For best results, this estimate should be made at the vibration level at which the system operates.

If motion of the structure is random rather than sinusoidal, motion of the mass will also be random and will have the characteristics of narrow band random motion. If the excitation has an acceleration density G in the region of the resonant frequency, the rms acceleration response of the mass is

$$a_R = \sqrt{\frac{\pi}{2} Gf_nQ} \qquad (5)$$

where

a_R is the rms random acceleration response in g,

G is the acceleration density in units of g^2/cps,

f_n is the resonant frequency of the normal mode in cps,

Q is the peak magnification factor of the normal mode for sinusoidal excitations.

The instantaneous acceleration response of a resonant specimen is shown in Fig. 6. Since the rms acceleration response can be calculated from Eq (5), the vertical scale has been generalized in the same manner used for Fig. 5 by dividing instantaneous acceleration by rms acceleration. Magnitude of instantaneous response as measured on the vertical scale then gives the acceleration of the mass as a fraction of the rms acceleration. The curve is for a typical structure resonant at 150 cps with a Q near 8. It may be noted that the waveform looks much like a 150 cps sine wave with a constantly varying amplitude and phase.

Although the curves in Fig. 5 and 6 do not appear similar, the probability of occurrence of specific accelerations for the two curves is the same. Acceleration response in Fig. 6 is less than the rms value 68 per cent of the time and exceeds three times the rms value only 0.3 per cent of the time. Period is for 0.1 second in which the acceleration is near a median value. For other similar periods the magnitude might be either much smaller or much larger, approaching either zero acceleration or exceeding three times the rms value on the peaks. Response of a single degree of freedom system, which has very little damping, is similar to the acceleration of an environment viewed through a narrow band pass filter.

The curve in color connecting peaks of instantaneous acceleration responses is called an envelope. Magnitude of the envelope fluctuates in a somewhat erratic manner, but an approximate fluctuation frequency can be observed. Since the fluctuating frequency is approximately equal to resonant frequency divided by Q of the normal mode in question, it is useful in estimating the Q of a resonance.

Predicting Component Reliability

Damage to components subjected to random vibration is closely related to damage caused by a vibrating single degree of freedom system. Most of the failures are caused by stress in the component proportional to the magnitude of the response. Stresses which cause failure under random motion excitation usually correspond to the response peaks exceeding two or three times the rms value.

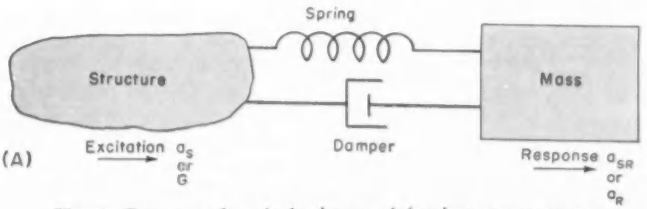
Preliminary sinusoidal vibration surveys should be made before random excitation to study durability of a component at each of the component resonances. This helps spot obvious component faults.

Since it is at the acceleration peaks that damage occurs, equating peaks caused by sinusoidal excitations to peaks caused by random excitations will cause similar failures. The peak sinusoidal response, which is equal to Q times the sinusoidal excitation, can be equated to a multiple N of the rms random response given by Eq (5), giving

$$a_{sR} = Qa_s = Na_R$$

Thus the peak acceleration excitation which will cause approximately the same damage as a random excitation G in the vicinity of the resonance becomes:

$$a_s = N\sqrt{\frac{\pi f_n G}{2Q}} \qquad (6)$$



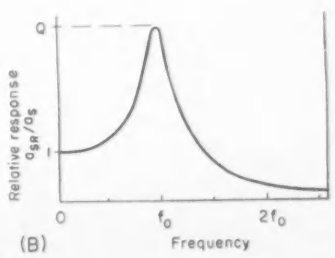


Fig. 7—Response of a single degree of freedom system to a sinusoidal excitation. (A) schematic of the system; (B) magnification of input motion. Peak magnification Q is related to the response of the system to random excitation.

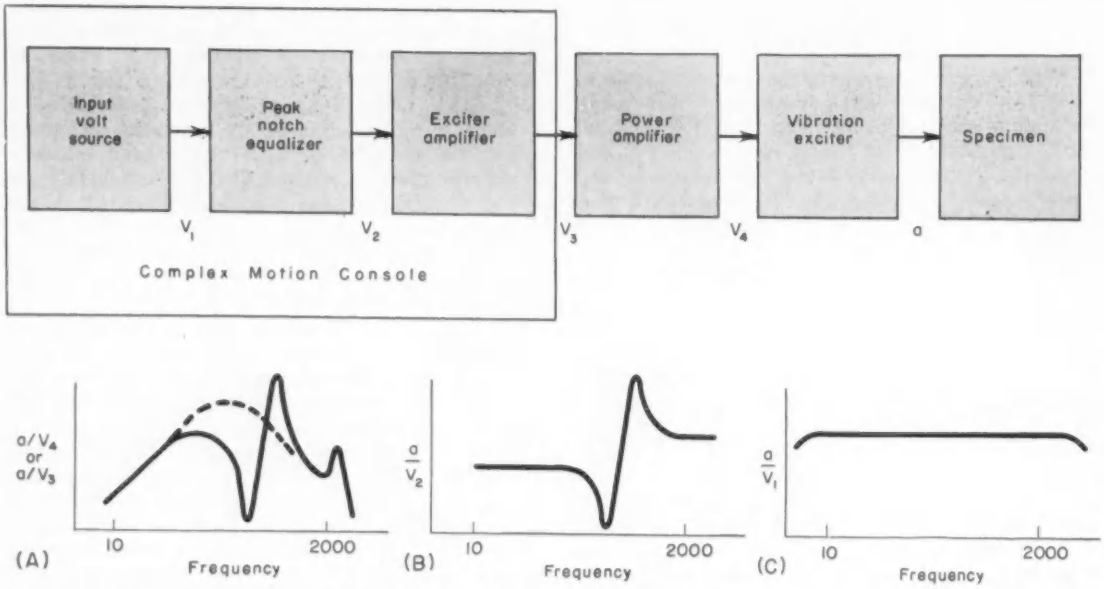


Fig. 8—Major components of a complex motion system to simulate a random environment. Curve *(A)* shows the characteristics of the vibration exciter before compensation; dashed line loaded, solid line with resonance. Curve *(B)* shows the result after an exciter equalizer is applied to the solid line in *(A)*. Curve *(C)* shows the final compensation resulting from a peak-notch equalizer added to correct for *(B)*.

where a, is in the units of peak g, and N is the ratio of the random damage level to the rms level.

A value of N equal to 2.5 gives reasonable correlation for most materials between observed damages caused by sinusoidal and by random excitations. For brittle materials, N should be raised to 3 or more and for very ductile materials a value below 2 is indicated.

If a component fails because of vibration, the designer may reduce damage by several ways. The addition of damping is almost universally helpful. The structure may also be stiffened or redesigned to use one of the new high-damping alloys (see "Manganese Copper High-Damping Alloys," *Product Engineering*, May 1956 page 135). Also, keeping the linear dimensions small will keep resonant frequencies high and improve conditions. Frequently the excitation in the environment is not uniformly distributed with frequency and the design can be improved by increasing or decreasing the resonant frequencies to regions where the motional excitation is low.

Simulation of Random Environment

Objective of laboratory simulation is to create random motion similar to that found in actual observed environments or predicted by theory. This motion can then be used to evaluate the durability of components or for qualification testing.

First step is to decide what acceleration the specimen should be subjected to and then obtain a voltage proportional to that acceleration. Finally, the laboratory equipment is adjusted to create an acceleration proportional to the voltage.

Laboratory equipment required to perform this simulation is called a "complex motion system" and consists of three major components. A vibration exciter shakes the specimen, a large electronic amplifier powers the vibration exciter, and a complex motion console supplies a modified voltage to the amplifier to create acceleration of a vibration table proportional to an input voltage. Sources of input voltage proportional to commonly desired accelerations are mounted in the console and others may be externally connected as desired.

A specimen and the three components of the system are shown in the block diagram of Fig. 8. The specimen is vibrated by an exciter driven by a power amplifier. The amplifier receives a modified voltage from the console which contains an input voltage source, a peak notch equalizer and an exciter equalizer. The symbol a in the diagram represents the acceleration of the specimen; voltage from the input voltage source is designated as V_1. Voltages at the other major points in the system are designated by progressive subscripts. It is desired that the acceleration of the specimen exactly reproduce the input voltage V_1.

Gain of a vibration exciter is the ratio of acceleration of the table and specimen to the voltage which drives the vibration exciter. However, the gain varies greatly with frequency. To obtain an acceleration proportional to input voltage the gain of the entire system from input voltage V_1 to the specimen acceleration a must be constant. By using equalizers in the console, the gain of the equalizers is adjusted to the inverse of the gain of the vibration exciter to make the gain of the entire system constant.

Two types of equalizers are required because the gain of the vibration exciter is not constant to start with, even without a table load, and each resonance of the specimen introduces a sudden variation in gain. The "exciter equal-

izer" compensates for the gain variation of the vibration exciter as modified by the non-resonant portion of the load. It is adjusted to have a gain which is inversely proportional to the vibration exciter gain. A "peak notch equalizer" compensates for the gain variation caused by a specimen resonance and has a gain characteristic that is a function of frequency. Several peak notch equalizers are normally used, one for each of the major resonances of the specimen. When properly adjusted, the gain of the console from V_i to V_s is inverse to the gain of the vibration exciter from V_s to the table acceleration a. Since the amplifiers used in the system have a very flat frequency response, the ratio of V_s to V_a is a constant. And since the amplifier gain is constant, the equalizers compensate for the vibration exciter and the acceleration is proportional to the input voltage.

A random voltage generator is used for the input voltage source and, with a constant gain, the specimen will be subjected to random accelerations. Other components usually added to the system to increase its flexibility and to protect it from component failure and operator abuse are: **a displacement limiter** to prevent the vibration exciter from hitting mechanical stops and jolting the specimen; **a variable bandpass filter** to adjust the bandwidth of input voltage; **an rms voltmeter** to read the rms magnitude of any voltage or acceleration; **accelerometers and cathode followers** to convert motion to voltage; **an oscilloscope** to view waveforms; **an amplitude protector** to prevent system failures from damaging the vibration exciter or specimen.

Selecting Test Equipment

The vibration exciter should have a displacement range adequate to handle the range of expected displacements and a force rating great enough to produce the required rms and peak accelerations for the expected range of test loads. Unfortunately, neither the peak to peak displacement nor the peak acceleration of a random motion is a well defined quantity. The displacements are random if the accelerations are random, and peak displacements and accelerations exceed three times the rms values 0.3 per cent of the time.

If displacement is limited to three times the rms value in each direction—a practice that has become standard—the peak to peak displacement is equal to 6 times the rms value and can be calculated from the acceleration density. For a wide band flat acceleration density spectrum the peak to peak displacement is

$$d_{pp} = \sqrt{\frac{1150 G_o}{f_L^2}} \qquad (7)$$

Where d_{pp} is the peak to peak displacement in inches. If the acceleration density spectrum is not flat, Eq (7) can be used to calculate an approximate value for peak to peak displacement by replacing G_o with G in the region of f_L.

The rms random force rating of a vibration exciter should exceed the rms random force requirement of the vibration test. The force requirement can be computed by the following equation:

$$F = WA \qquad (8)$$

where F is force in rms random lb, W is weight in lb of the entire moving element assembly, and a is acceleration on the moving system in rms random g. The rating of the vibration exciter is equal to 0.707 times the peak sinusoidal force rating. For random motions, peak accelerations equal to at least three times the rms acceleration are desired. For this reason vibration exciters for random motion are designed to produce peak forces equal to three times the rms force rating.

Selection of an amplifier is determined by the random force to be produced and the characteristics of the particular vibration exciter used to produce this force. It must be capable of producing the high voltage and current peaks required for forces equal to three times the rms force rating of the vibration exciter. Frequency response of the amplifier must be flat if the operation of the equalizers is not to be affected, and should be accompanied by good transient response to reproduce the waveshapes encountered in operation. In addition, the amplifier must have low distortion to prevent the undesired excitation of any resonance by distortion products.

Approximate size of equipment to perform various tests is given in Table I. The two systems listed are probably the smallest and largest sizes currently popular. The smaller system will drive a specimen weight or payload of 25 lb to an rms acceleration of 20g. This is the rms level used in the example calculated above which had an acceleration density of $0.2g^2$/cps and a band width of 2000 cps. The larger system listed will drive a 257 lb table load to the same rms acceleration. Each of the systems will produce peak forces up to three times the rms force listed.

Table I—Amplifier-Exciter Requirements

Exciter	Amplifier	Payload, lb.
RMS Random Force	KVA	20 g RMS acceleration
840	7.5	25
7000	90	257

If the force rating of a system is inadequate to drive the specimen to the desired acceleration density over the entire 2000 cps band, it is possible to divide up the band into two or more frequency ranges and test each range separately. By this procedure, acceleration densities can be achieved in restricted frequency ranges considerably greater than would be possible if the entire frequency band was tested at the same time. For example, the large system is too small to test a 400 pound object to an acceleration density of $0.2g^2$/cps over the entire frequency band from 15 to 2015 cps at one time. If, however, this test is broken into four tests, each for 500 cps wide band, an acceleration density of $0.2g^2$/cps can be obtained. This procedure is based on the assumption that a test which successively tests four separate 500 cps frequency bands is a valid test. Such an assumption is only justified in an emergency.

Curves in (A) of Fig. 8 show the gain-frequency characteristic of the vibration exciter. This is the characteristic previously discussed that must be compensated by the equalizers. Dashed curve in A represents the gain characteristic of the unloaded vibration exciter. Although the gain characteristics in the low frequency range are not constant,

the variation with frequency is relatively gradual. The peak occurs at a high frequency which is common for all vibration exciters and is caused by an axial mode resonance within the moving structure itself in which the center of the table moves in opposition to the motion of the main driving coil.

As the frequency is raised above the resonant frequency, it becomes increasingly difficult to supply an adequate force to the specimen. A practical upper frequency limit is about twice this resonant frequency and, whenever possible, the frequency band of operation should be kept below this frequency.

The solid line in (A) shows the gain of a vibration exciter on which is mounted a specimen with a single severe resonance. Resonance of the specimen introduces a large notch and peak to the gain characteristic. At high frequencies the resonating mass of the specimen is effectively isolated and the gain curve approaches the gain for the unloaded vibration exciter. At low frequencies, the specimen looks like a heavy dead load applied to the table and the same acceleration requires larger voltages than for the unloaded case.

As frequency is increased through the resonant frequency of the specimen, the gain drops to a minimum and then rises to a peak with the minimum point at the resonant frequency of the specimen. Since the specimen acts like a dynamic vibration absorber at this frequency, large forces and large voltages are required to obtain the same table acceleration as at lower frequencies. The gain maximum occurs at the frequency of a combined resonance of the specimen and moving assembly, and very little force is required to obtain large accelerations.

The exciter equalizer compensates both for the gradual slopes in the low frequency region and for the sharp peak in the high frequency region as shown in (B). This is accomplished by creating in the equalizer an exact reciprocal of the transfer function of the unloaded vibration exciter and attached nonresonant mass.

Curve in (C) is caused by a peak-notch equalizer which compensates for both amplitude and phase variations, not only in the vicinity of resonance, but also over the full frequency band of operation. This complete compensation is achieved by creating, in the peak-notch equalizer, the exact reciprocal of the modification to the vibration exciter transfer function caused by a resonance in the specimen.

Since most specimens have a number of resonances, not just the one illustrated in Fig. 8, a number of Peak-Notch Equalizers are used, all connected in tandem so that their gain-frequency characteristics multiply.

Before the test equipment is adjusted, random motion studies are taken of the structure on which the components are to operate. Usually a set of curves similar to the solid line in Fig. 3 are obtained from various locations in the structure and at different times. The curves will vary; therefore, a component test specification derived from these curves should be made more severe than the expected environment. If all the components in a device survive the random vibration tests, the device is considered reliable and can be expected to perform its intended function.

Lightweight Nut Design Based on High Strength Material

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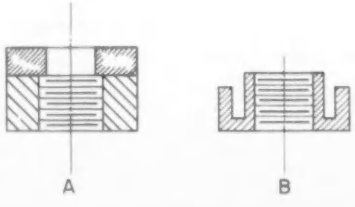
Bolts and screws of alloy steel heat-treated to 160,000 psi tensile strength have been standardized by the National Aircraft Standards Committee. Thread lengths and head sizes on these new parts were decreased in some instances for weight and space-saving purposes. The result was an increase in strength-weight ratio of about 30 per cent.

These changes to the bolt and screw standards were minor, however, when compared with the entirely new design concept. A lightweight self-locking nut was developed which depended upon high-strength material for its function and physical properties.

A tubular configuration is stamped from strip or sheet of annealed, heat-treatable steel and threaded to standard tolerances. The upper portion is "closed" a few thousandths of an inch to impart the self-locking function. (Viewed from the top it assumes an elliptical rather than circular shape.) The part is heat treated to a value of about 200,000 pounds per square inch.

The threaded wall must be thin and of high strength in order to permit resilient operation of the self-locking element and to withstand the loads such as hoop tension to which the nut is subjected in service.

In the drawing is the familiar hex nut of low strength material with the auxiliary locking device. The new concept (b) is of equal or higher axial strength but height is reduced to that of a shear nut. Note that the design of the new lightweight hex nut involved drawing up a hexagonal wrenching apron around the basic nut element. In the common ¼-28 thread size, for example, the weight of the standard design was 9 lb per thousand; the weight of the new design is about 4 lb per thousand.



Note that the auxiliary locking device has been designed out of the new part. Also, further reduction in the amount of material is obtained by virtue of the annular recess which divorces the main load-carrying nut element from the wrenching element.

This new hex nut may be wrenched internally as well as externally and therefore another great weight saving is possible in design of new aircraft as the large amount of wrench clearance formerly required surrounding a hex nut is obviated. Flange widths can be reduced as the nuts can be nestled closer to the web or body of the aircraft structural part.

Similar weight and space reduction is possible with anchor nuts of the new design, both of the fixed and floating types.

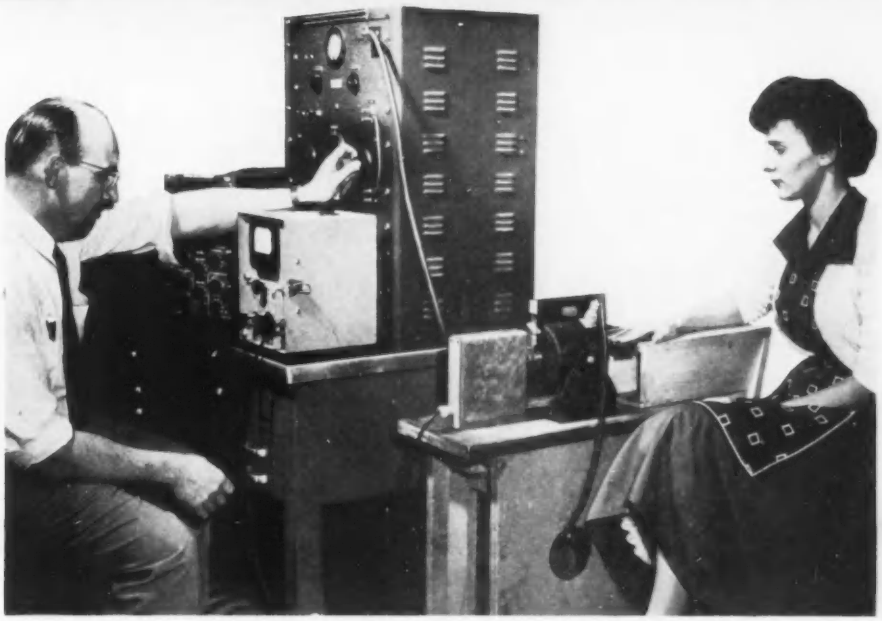


Fig. 1—Equipment used to determine sensory perception level. A calibrated secondary vibration measuring standard, unaffected by damping produced by tested individual determines vibration amplitude.

Touch and Vibration Sensitivity

Maximum and average fingertip and hand sensitivities to a vibrating mass are determined and plotted as a function of frequency and amplitude of the oscillation.

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Development Engineer, Balancing Machine Division, Gisholt Machine Co.

PERMISSIBLE VIBRATION AMPLITUDE for various pieces of equipment is generally established on the basis of: ability of components such as bearings and supporting housing to withstand additional loading imposed by vibration; loading effect that vibration may have on associated members in ultimate installation; and the comfort or initiation levels of persons using and handling equipment in operation at home or in plants.

Each of these effects of vibration must be recognized and their relative importance determined when establishing a vibration tolerance for a given piece of equipment. The maximum vibration amplitude that can be tolerated must be determined independently for each effect and for each application with the limiting amplitude establishing the overall vibration tolerance.

In designing a piece of equipment, it is normally feasible to analytically determine the loading and consequently the stresses and fatigue effect produced by a vibration of a given amplitude at a known frequency. However, the human response to this same vibration cannot be calculated and empirical data must then be used to establish the maximum vibration amplitude that can be tolerated comfortably by the persons using the equipment. In the past, psychologists as well as engineers in the automotive, power plant, and other fields have investigated the human response to vibration based on both frequency and amplitude. Their published results have provided empirical data that has been extremely useful to the design engineer.

Unfortunately, this work had been done to satisfy the requirements of a specific field and consequently applies only to the speed range likely to be encountered in that field. Little or no published data is available for speeds above 3600 rpm such as produced by household appliances, power tools, and other types of equipment that use series or high speed motors. To provide a guide for higher frequencies, human vibration sensory perception level at frequencies up to

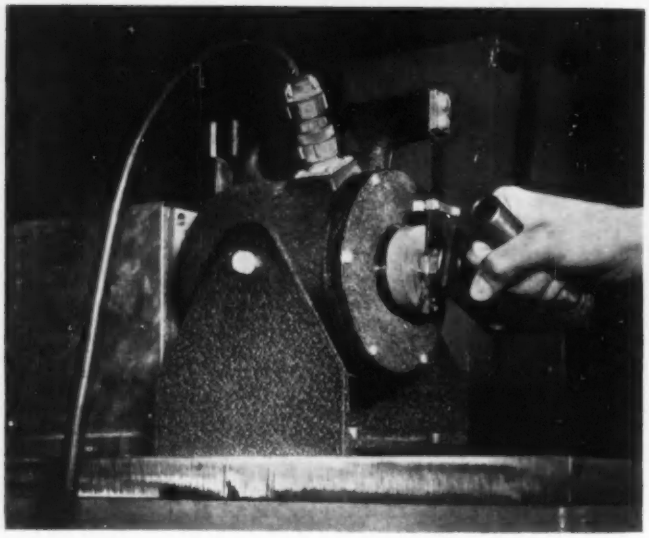

Fig. 3—Hand grip type of vibration contact similar to that found in mixers and other portable power tools was simulated by mounting a hand grip on the electro-magnetic exciter.

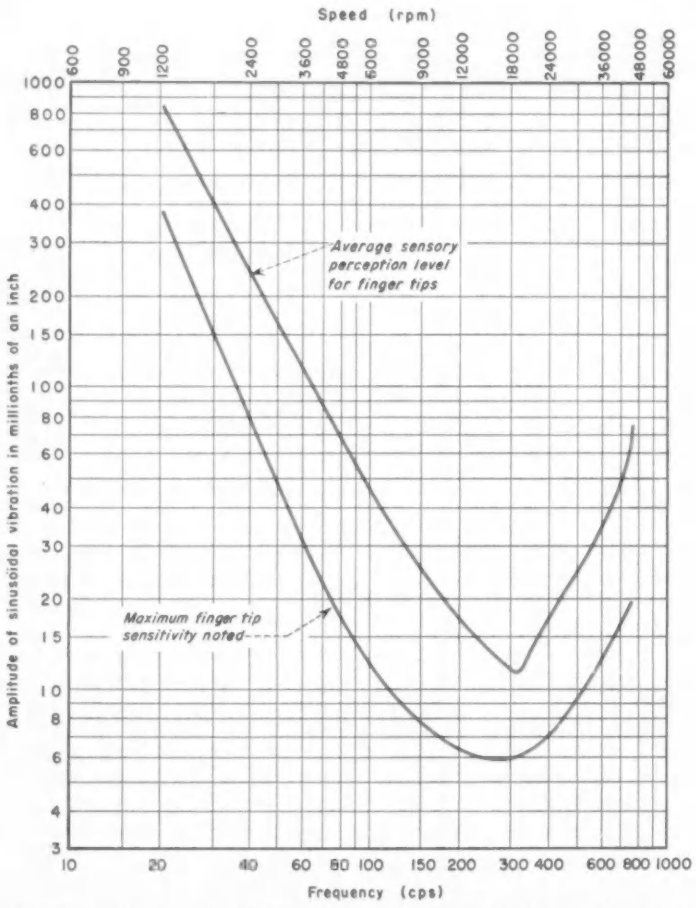

Fig. 2—Vibration amplitude perception level of the finger tips. Vibration is sensed in a manner similar to that used when "feeling" an object for vibration. The path of motion of the vibrating block is along a line parallel to the arm.

700 cycles per second (42,000 rpm) were determined and plotted.

As conditions of test influence amplitude at which a vibration becomes perceptible the conditions must be understood to make the data applicable for the design engineer. The equipment used is shown in Fig. 1. An electro-magnetic exciter was used to give simple harmonic motion to a steel block. Individuals under test touched the vibrating block with their finger tips in a manner similar to that normally used when "feeling" an operating unit for vibration. The path of motion of the vibrating block was along a line parallel to the arm.

At a given frequency, vibration amplitude of block was increased from zero until the vibration was sensed. Vibration amplitude was then decreased from a large value until vibration was no longer noted. Repeated indications of this amplitude threshold at which vibrations were sensed by a given individual at a given frequency were extremely consistent.

Vibration sensory perception level of twenty-five tested individuals had a similar amplitude-frequency relationship, with considerable variation in individual sensitivity. This variation along with the effect of human judg-

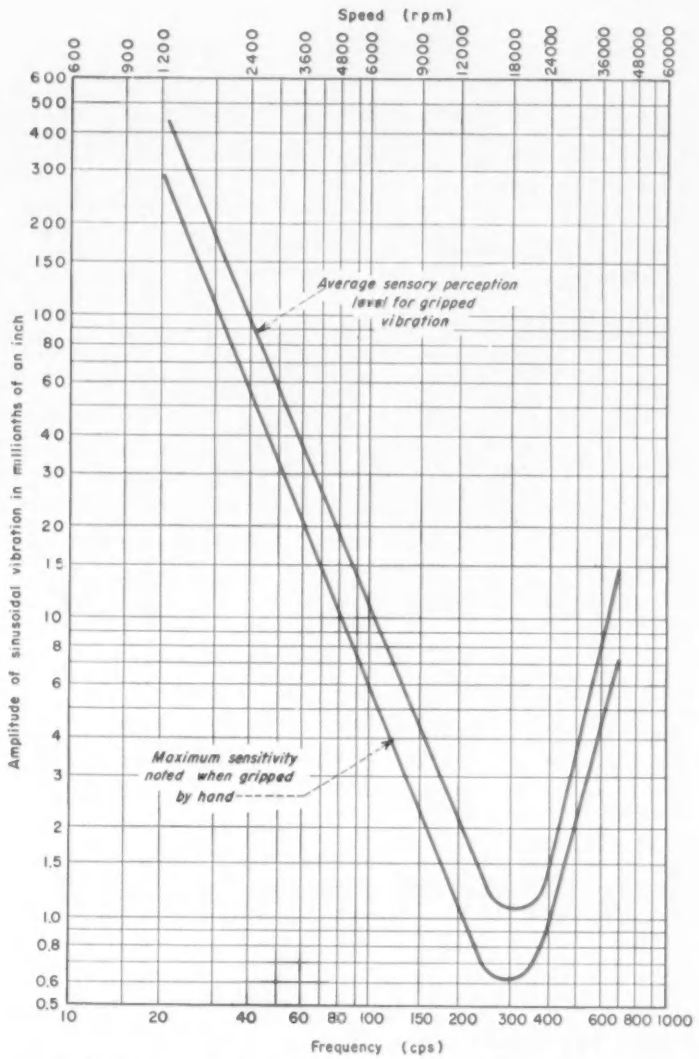

Fig. 4—Vibration amplitude perception level when the vibrating object is gripped by hand. A comparison of these curves with Fig. 2, shows that a person is considerably more sensitive to a vibration that is gripped than to one that is touched.

ment makes it impractical to attempt to classify the vibrations as smooth, fair, rough and the like. Only the amplitude at which the vibrations became perceptible were considered.

Average sensory perception level as plotted in Fig. 2 is a guide that supplements existing lower frequency data. Maximum individual vibration sensitivity (plotted in color) is the perception level of the most critical user.

Perceptible amplitude varies inversely with approximately the 1.8 power of frequency up to 300 cps and as frequency is increased above this value, human sensitivity to vibration begins to decrease. Unfortunately, this reversal in the curve at 300 cps has little effect on vibration tolerance; for equipment operating at speeds above 18,000 rpm, stress and loading produced by vibration usually establishes allowable vibration limit.

Human response to vibration changes for different conditions of contact with vibration. To illustrate this consideration, a hand grip was mounted on the electro-magnetic exciter to simulate the hand mixer and other portable power tools shown in Figure 3. Vibration sensory perception levels for individuals tested for this type of contact are shown in Fig. 4. A comparison of curves of Figs. 2 and 4 shows that a person is much more sensitive to a vibration that is gripped than to one felt at the finger tips.

Effect of noise on vibration perception level was also considered since it is logical to think of the reduction of noise and vibration as a single problem. The finger tip sensitivity test was repeated with individuals under test exposed to noise at the frequency of the vibration being investigated. The noise level was held constant at 78 db, a value similar to the level that would be encountered in an office with tabulating machines operating. There was no noticeable change in the individual's sensory perception level when this noise was introduced, indicating that noise and vibration should be considered as separate problems when establishing a vibration tolerance.

EDITOR'S NOTE—Methods of vibration control have had extensive coverage in *Product Engineering* in recent months. A selected group of these articles is listed below in chronological order.

"Analysis of Oscillatory Motion Using High Speed Photograhy," W. G. Hyzer, June 1956 page 135. Derivation of timing and measuring accuracy; study of a vibrating spring and motion of a solenoid armature.

"Oscillatory Accelerations," Joseph F. Sodaro, January 1956 page 221. Alignment chart to determine acceleration in g's of a vibrating body.

"Selecting Vibration Isolators," September 1955 page 184. Five point design procedure, and 11 types covering loads from ounces to tons.

"Shock Isolation," Walter W. Soroka, June 1955 page 167. Method of analyzing displacement and inertia loads on an elastically mounted structure subjected to impact, based on half sine-wave pulse.

"Keeping Products Quiet," D. F. Muster, December 1954 page 140. Physiological effects of noise; magnetic, air, and mechanical noise sources in induction motors; methods for reducing noise to desired levels.

"Vibration of Machines on Flexible Structures," Walter W. Soroka, April 1954 page 190. Determination of spring constants of typical structural elements, application to composite structures and vibration isolation by proper tuning of structure and mounts.

"Vibration Isolation of Machines," Sheldon E. Young, February 1954 page 146. Selection of isolators for three, four, and six point mounting.

"Damping Characteristics of Glass Fibers, Sol Musikant, February 1954 page 166. Load-deflection characteristics of glass fiber mat, shear strength, transmissibility and temperature range.

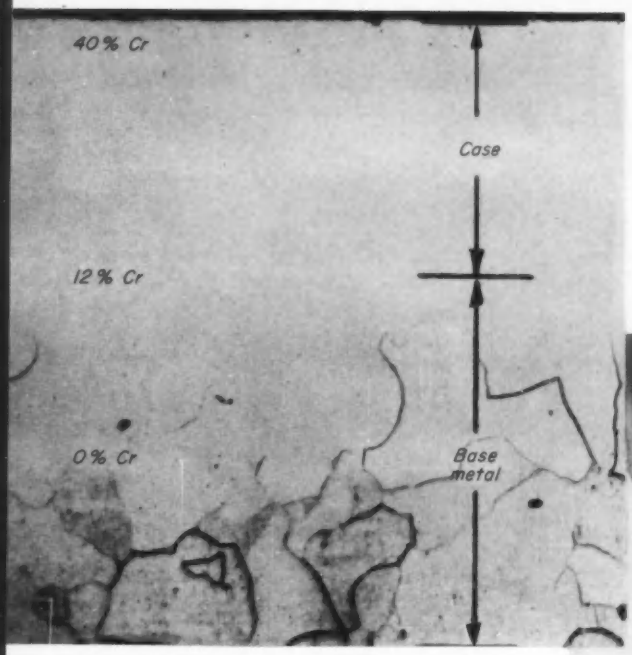

Fig. 1—Chromized case at large magnification, showing continuity between base metal and case. Base metal: SAE 1010.

Fig. 3—Corrosion resistance of iron castings exposed to same atmosphere for same length of time. Left: untreated. Right: chromized.

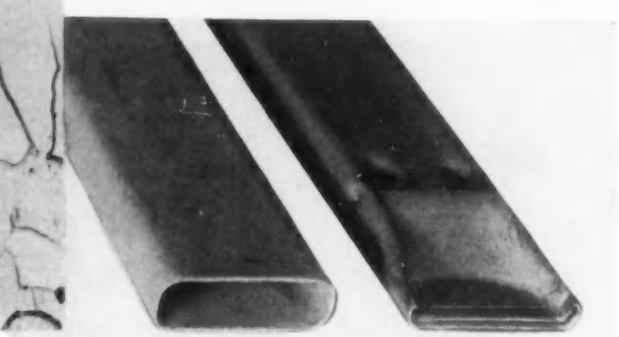

Fig. 2—Formability of ductile case is shown by the strip heater casing, right, crimped after chromizing. Uncrimped casing, left.

Chromizing for Resistance to

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RICHARD L. WACHTELL, Technical Director
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CHROMIZING, or surface diffusion of chromium in most ferrous and some non-ferrous metals increases their resistance to oxidation, corrosion and wear while conserving critical materials. Commercially, the chromizing process is carried out by the "pack" method, which consists of placing the parts in a powdered compound in special alloy retorts and processing at high temperature. Gaseous chromium compounds evolved reach all surfaces of the parts being treated, including recesses, threaded holes, cracks, and even the surface pore structure of parts produced by powder metallurgy techniques. At these surfaces, the volatile chromium compounds interact with the base materials, depositing metallic chromium atoms which diffuse inward and alloy or react with the elements of the base alloy. What results is either a ductile or a hard case, integrally bonded to the base metal, having characteristics which depend largely on the composition of the treated metal parts.

The Ductile Case

With steels having a low carbon content, the diffusing metallic chromium forms a new alloy. SAE 1010 forms an iron-chromium alloy case with chromium content decreasing from approximately 40 per cent at the surface to zero at the root, Fig. 1. Depth of case may be controlled to a commercial maximum of 0.003 in. Characteristic of this case is good resistance to scaling and corrosion at elevated temperatures. After heating at 1200F for 1000 hours, chromized SAE 1010 steel gained only 2 to 5 mg/sq cm, a weight gain in the same range as the one found in Inconel and such stainless steels as type 430, type 446 and type 302. Similarly exposed nickel silver gained 67 mg/sq cm, unprotected steel 1620 mg/sq cm, and copper plate 2780 mg/sq cm.

When operated at temperatures below 900 F, the ductile case does not discolor, resists attack by combustion gases, and prevents carbon penetration into the steel. The case is continuous and has considerable ductility, so that relatively severe forming operations, Fig. 2, can be performed on the parts after the case has been produced.

Typical Applications of the Ductile Case

Material	Form in which Parts are Supplied	Properties Needed	Special Features	Material Replaced
SAE 1010	0.030 in. wall tubing for electric heater casing	Oxidation resistance at 1200 to 1400 F. Ductility of case and core.	Tubes have to be formed and steel stamped (trade name and catalog numbers) after chromizing	430 stainless steel
SAE 1010	0.030 in. wall tubing for arc light shield	Oxidation resistance and good thermal conductivity	Permits simplified design	Single chromized SAE 1010 tube replaced hollow assembly made from two 321 SS tubes, welded at each end
Ingot Iron (Armco or enamelling iron)	Expanded metal 20 ga., 0.093 in. offset for gas broiler radiants	Resistance to gas flame at 1400–1500 F, intermittent operation with rapid heating and cooling cycles	Deep case obtainable with mild processing conditions. Cannot be formed after chromizing	430 stainless steel
Ingot Iron	Precision castings. Aircraft relay parts	Corrosion resistance in humid atmosphere	Case does not interfere with magnetic properties	Improvement over electrolytic coatings.
SAE 1117	Screw machined parts for soldering-iron cores and shells	Oxidation resistance (no scaling) up to 1000 F.	Low machining cost but corrosion resistance is reduced by presence of S. No forming operation should be performed	Improvement over copper alloys and stainless steel
Iron powder	Sintered parts for home appliances	Corrosion resistance in water and magnetic permeability superior to 430 stainless	Pores are sealed to prevent water from penetrating unprotected interior	Solid 430 stainless steel.
Iron powder	Molded powder metal parts	Improved toughness so as to eliminate brittle failure in the field	Rust resistance achieved at the same time	Improvement over plain iron powder sinterings

Corrosion and Wear

How gaseous diffusion of Chromium produces either ductile or hard surfaces on steel parts. Influence of base metal on the characteristics of the case, and typical applications.

In almost all instances, the fundamental character of the steel to which the case is applied remains unchanged, no embrittlement takes place, and the surface produced is resistant to wetting by molten metals. One exception is Armco iron, which becomes embrittled in the process. Resistance to corrosive media like fuels and combustion gases at elevated temperatures is high. Fig. 3 shows the effect of chromizing on an iron casting exposed to corrosive atmosphere.

Since the case is produced at high temperatures and the parts are cooled slowly, the chromizing operation leaves steels in the fully annealed condition. When required, a magnetic anneal can be produced during the chromizing process. Generally, no subsequent heat treatment or finishing is needed.

After chromizing, low-carbon steel can be staked, embossed, spun, crimped, drawn, and bent. Parts can be fusion welded with stainless steel welding rods; they can also be welded by projection, spot, or seam welding techniques; or they can be brazed using a fluoride flux and slightly higher than normal temperatures. Soldering is possible, but special techniques must be employed.

The Hard Case

Chromium's tendency for preferential combination with carbon causes a different type of case to be formed when diffusion in high-carbon materials takes place. This case, being primarily made up of chromium carbide, is very hard, and finds application where wear or abrasion resistance is desired.

Materials on which this carbide case is formed by the chromizing process include the cast irons, plain carbon steels containing at least 0.40 per cent carbon, and tool steels. Hardness must be determined with a micro-hardness tester at very low loads: with 10 gram load VPH

Some Applications of the Hard Case

Material	Form in which Parts are Supplied	Properties Needed	Special Features	Material Replaced
SAE 1018 deep carburized	Upset parts	Superior wear resistance in contact with abrasive material	Process eliminates need for conventional hardening	Improvement over heat treated steels
AISI 4340	Forgings for aircraft accessory	Operate at 900 F and over, are exposed to all types of outdoor atmosphere	Corrosion resistance has to be maintained through thermal cycling and in the face of some wear. Parts are heat treated for fatigue strength	Improvement over heat treated 4340. Replaces stainless steel
Sintered iron powder, deep carburized	Molded powder metal sprockets for driving chain saw.	Resistance to abrasion on chain saws operating in sandy conditions	Material toughened reducing edge failures	SAE 52100 bar stock. Improvement over plain iron powder sinterings
SAE 52100	Wire forming tool machined from bar stock	Metal to metal wear, sliding contact	Steel core is heat treated after chromizing without damage to hard case	Improvement over hardened tool steels
1.2% C steel	Cutters with multiple cutting edges for leather	Extended cutter life between grinds	Cutters can be sharpened by careful grinding on one face adjacent to the edge, preserving case on opposite face	18–4–1 high speed steel
A-2 Tool steel	Wiping dies for automobile trim	Resistance to wear and galling in contact with straight Cr-stainless steel	Small tools hardened directly from chromizing heat, eliminating distortion and bright finishing	Heat treated aluminum bronze
Grey Iron	Cast parts for kitchen equipment	Rust resistance in humid atmosphere and in contact with detergents	Large cost savings compared to stainless steel castings	Cast stainless steel

Applications Using Special Alloys and Nonmetallic Base Materials

Material	Form in which Parts are Supplied	Properties Needed	Special Features	Material Replaced
AISI 4130	Telescoping tubes for aircraft engine control	Resistance to seizing at 1000 F	Maintains dimensional accuracy	No other material successfully met requirements
Type 321 stainless steel	Machined pins. Aircraft accessory	Eliminate galling at elevated temperature in slow rotation	Austenitic stainless steel is used for its high temperature strength and stability	No other material successfully met requirements
HS21 and Stellite 31	Precision castings for special turbine	Erosion resistance at high temperature without sacrificing high temperature strength	Some alloys respond to precipitation hardening after chromizing	
Molybdenum and Tungsten	Flat strip or machined parts. Brazing mandrels for vacuum tube manufacturing	Oxidation resistance without danger of peeling in numerous heat cycles. Must resist attack by braze metal	Chromized molybdenum forms good glass to metal seals	Chromium plated tungsten and molybdenum
High nickel alloy	Pins for spark plug electrodes	Resistance to erosion by combustion gases and electric spark		Improvement over same material not chromized
Graphite	Machined components	Improved oxidation resistance	Thin, hard carbide case is formed	Improvement over graphite not chromized
Titanium carbide-base cermet	Presintered, machined and final sintered	Improved oxidation and wear-resistance	Chromizing may make the use of iron binders (in place of Ni and high alloys) feasible	

numbers up to 2300 are obtained, indicating that the material is almost as hard as cemented carbide. This high hardness is characteristic of the carbide case, no additional heat treatment being required to obtain it.

As with the low-carbon steels, so here too, the steels come out of the chromizing treatment in the fully annealed condition. The parts may then be given another heat treatment as required without affecting the properties of the case.

The chromium carbide case has been tested for wear resistance against non-ferrous metals, asbestos base compounds and such non-metallic materials as wood, leather, nylon, cotton, paper, and jute with very satisfactory results. The case also resists erosion by molten metal and by

molten glass. Low-carbon steels may be carburized before chromizing, in order to obtain this hard chromium carbide case.

Influence of Alloying Element

Carbon is one of the most powerful constituents in its effect on the diffusion rate of chromium into steel. Under otherwise equal processing conditions, case depth is smaller the higher the carbon content of the base steel.

Some elements retard the diffusion of chromium, producing a shallow case: nickel is typical. Other elements, one of which is silicon, assist the formation of deeper cases.

Some alloying elements enter into the exchange or diffusion reaction, affecting the character of the case. Instead of straight iron-chromium alloy, complex alloy cases are formed when other constituents are present, even in very small quantities. The type of complex alloy formed influences the corrosion resistance, the hardness and the surface smoothness of the case. Some stainless steels experience an improvement in properties by chromizing. Results of special tests performed on two stainless steels are shown in Table I.

Alloy Selection

Choice of material out of which the parts are made is governed by service function. When chromizing is considered and a case with special properties is required, then the alloy may be selected on the basis of the type of case it forms on chromizing. Occasionally, the part may be pretreated in order to produce a specific type of case.

Research now in progress indicates that some non-ferrous and even non-metallic materials may be chromized successfully.

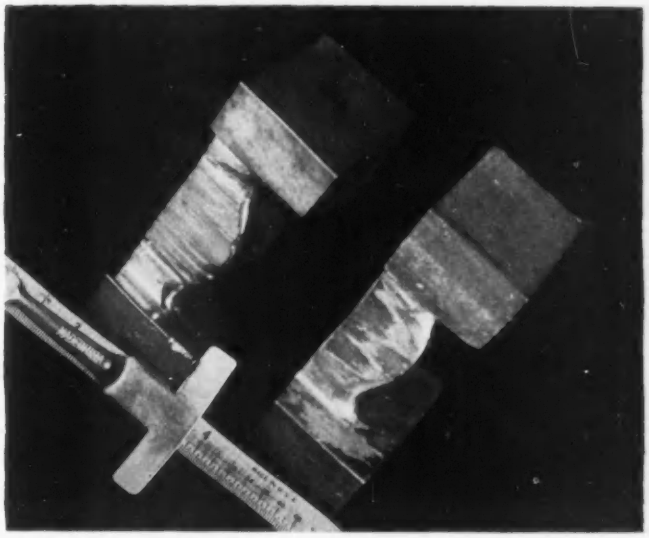


Fig. 4—Wear of wiping dies used to form type 430 stainless steel. Left: aluminum bronze after 3000 pieces. Right: tool steel with hard chromized case after 100,000 pieces.

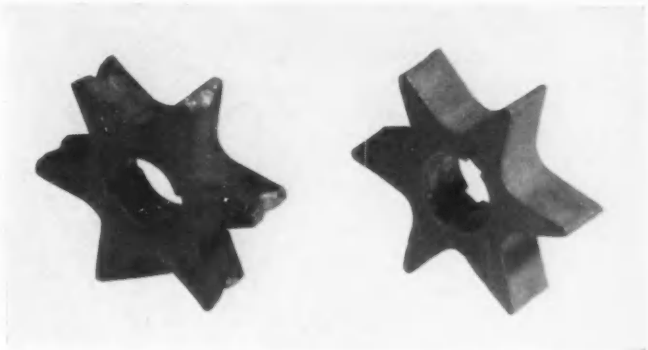


Fig. 5—Wear of high carbon steel sprockets made by powder metallurgy, after exposure to same abrasive condition for same length of time. Left: untreated. Right: chromized.

EDITOR'S NOTE—The process described in this article was developed in England, where it has been in commercial use for about ten years. Introduced in the United States about five years ago, it has now been in production for about three years. Two other chromizing processes have also been developed, one in Germany, one in France. They differ from the one described in this article in that the carrier gas is formed outside of furnace and piped in. Flow control of the gas is critical, and operation is more complex, making the processes more expensive.

Work is now in progress to adapt the British process to produce nickel diffusion.

Other processes for production of surfaces with special properties have been reported in *Product Engineering* in recent issues. "Flame Plating for Wear Resistance," September 1956 page 202, describes a process in which hard surfaces are produced by detonation deposition of special materials on the parts. "Developments in Sprayed Metal Coatings," June 1956 page 194, reports latest designs of powder spray guns and discusses the fusing properties of alloys sprayed by this equipment. "Alloy Plating," September 1955 page 136, describes plating procedures for electrodeposition of some alloys and properties of plated parts.

Table I—Effect of Heat Cycling on Weight Change

Steel Type	Duration of test, hrs	Range of cycle	Period of cycle	Weight change, gm/cm²	
				As received	Chromalized
310	400	300 to 1600 F	30 minutes	−0.1703	+0.0001
304	400	300 to 1600 F	30 minutes	−0.1265	0

Other articles include "Hard Chromium Plated Parts," 1956 Design Digest Issue, page C2. Another article on page C8 in the same issue, "High Temperature Coatings for Metals," includes data on diffusion, refractory and low emissivity coatings. Also, "Nickel and Chromium Electroplates for Aluminum," in the 1955 Design Digest Issue, page C2.

Protection of surfaces by dipped aluminum coatings will be covered by an article in preparation for a forthcoming issue.

Unusual Applications of

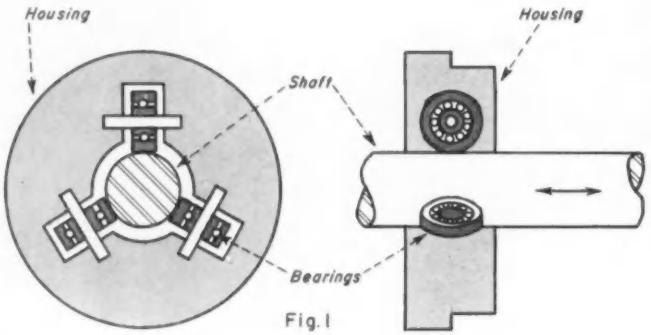


Fig. 1

FIG. 1—BALL-BEARING SLIDES. Six miniature bearings accurately support a potentiometer shaft to give low-friction linear motion. Three bearings are located in each end 120 deg radially apart to assure alignment and freedom from binding.

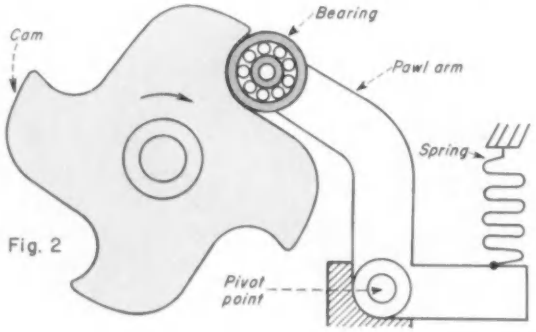


Fig. 2

FIG. 2—CAM-FOLLOWER ROLLER. Index pawl on a frequency selector switch uses bearing for a roller. Bearing is spring loaded against cam and extends life of unit by reducing cam wear. This also retains original accuracy in stroke of pawl arm.

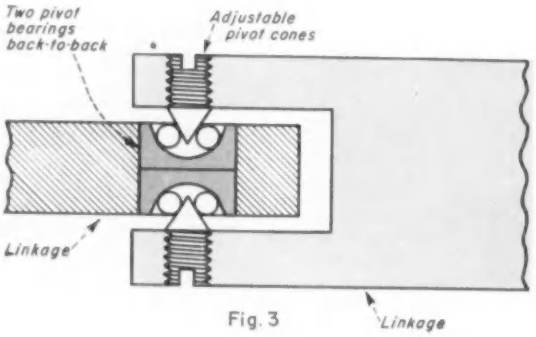


Fig. 3

FIG. 3—SEAT FOR PIVOTS. Pivot-type bearings reduce friction in linkages especially when manually operated such as in pantographing mechanisms. Minimum backlash and maximum accuracy are obtained by adjusting the threaded pivot cones. Mechanism is used to support diamond stylus that scribes lines on gunnary telescopes.

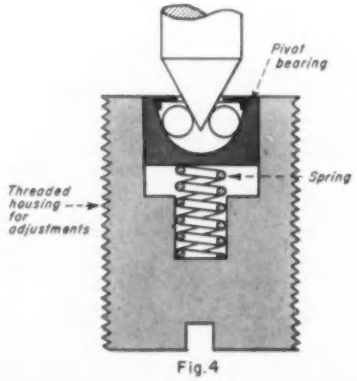


Fig. 4

FIG. 4—SHOCK-ABSORBING PIVOT POINT. Bearing with spherical seat resting on spring acts as a pivot point and also absorbs mild shock loads. Used on a recording potentiometer that is temperature controlled. Spring applies uniform load over short distances and gives uniform sensitivity to the heat-sensing element.

Miniature Bearings

R. H. CARTER
Chief Engineer
Miniature Precision Bearings, Inc.

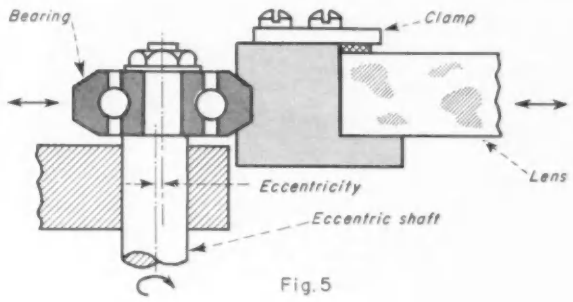


Fig. 5

FIG. 5—PRECISE LINEAR ADJUSTMENTS obtained by rotating the eccentric shaft thus shifting location of bearing. Bearing has special-contoured outer race with standard inner race. Application: lens with grids for an aerial survey camera.

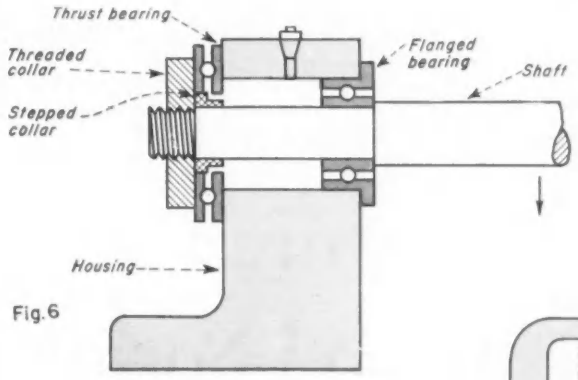


Fig. 6

FIG. 6—SUPPORT FOR CANTILEVERED SHAFT obtained with combination of thrust and flanged bearings. Stepped collar provides seat for thrust bearing on the shaft but does not interfere with stationary race of thrust bearing when shaft is rotating.

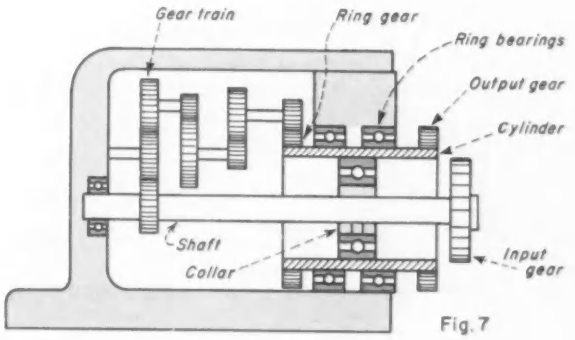


Fig. 7

FIG. 7—GEAR-REDUCTION UNIT. Space requirements reduced by having both input and output shafts at same end of unit. Output shaft is a cylinder with ring gears at each end. Cylinder rides in miniature ring bearings that have relative large inside diameters in comparison to the outside diameter.

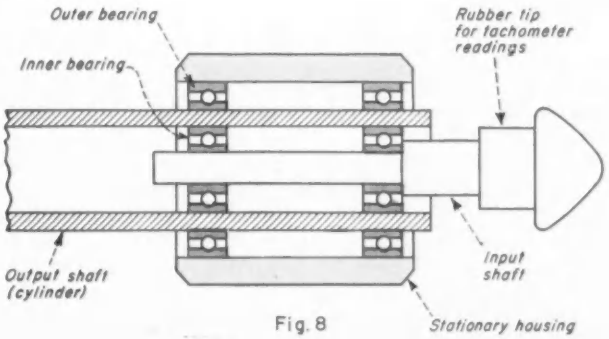


Fig. 8

FIG. 8—BEARINGS USED AS GEARS. Manually operated tachometer must take readings up to 6000 R.P.M. A 10-to-1 speed reduction was obtained by having four bearings function both as bearings and as a planetary gear system. Input shaft rotates the inner race of the inner bearings, causing the output shaft to rotate between inner and outer bearings. Bearings are preloaded to prevent slippage between races and balls. Outer housing is held stationary. Pitch diameters and ball sizes must be carefully calculated to get correct speed reduction.

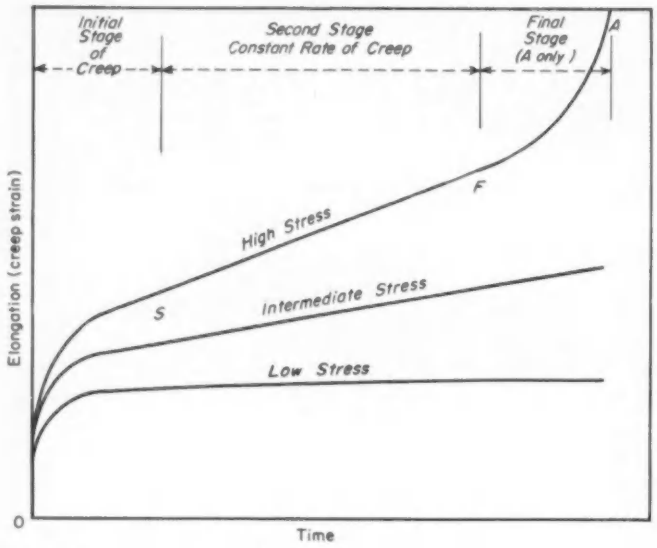


Fig. 1—Creep-time curves. Creep specimen is a standard annealed carbon steel rod.

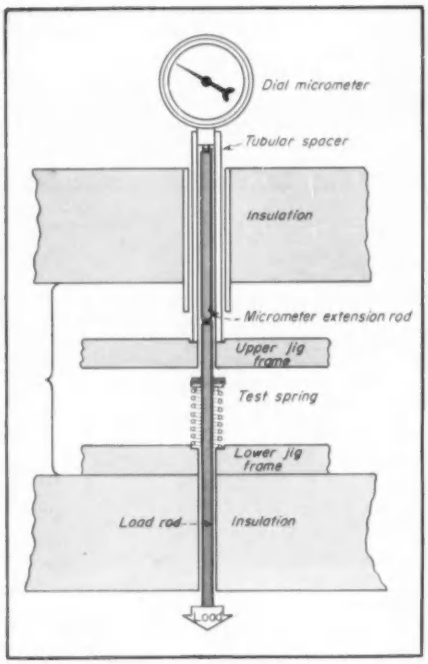


Fig. 2—Test set-up. Method of taking creep easurements of helical wire springs while in furnace.

High Temperature Creep of Coil Springs

C. T. EAKIN
Materials Engineering Dept.,
Westinghouse Electric Corporation

Music wire and Type 304 steel tested for creep at 20 C, 150 C and 250 C. Test method, creep-time and creep-stress relationships. Data indicates that curves can be extroplated for higher values when plotted on logarithmetic coordinates.

CREEP IS DEFINED as a gradual deformation of materials in the direction of applied stress, usually over a long period of time and at elevated temperatures. It is the subject of intensive study and investigation primarily because of the continuing increase in operating temperatures in many fields. The problem is approached experimentally by applying tensile stress of uniform distribution and constant magnitude to a standardized specimen for the required period of time. Creep is recorded as a progressive increase in gage length of the specimen with increments of time.

Tensile specimens are usually heat treated for structural stabilization at the approximate temperature of the test or service. In most instances, this treatment approaches a soft anneal leaving the material free from residual stresses. Helical springs, however, differ considerably from the uniform diameter and definite gage length test specimen. In contrast to the pure tension and approximately uniform stress distribution in standard creep specimens, stress in a helical spring is mainly torsion and varies from approximately zero at the center of the wire to a maximum at the surface. Stabilization treatment for springs must be held to much lower temperatures and results merely in the relief of peak residual stresses. Thus cold-formed springs have exceedingly large and complex stresses.

These variations effect not only the numerical value of the creep, but also require the use of a different basis for comparison. When standard annealed carbon steel tension specimens are used, creep is divided into three stages, Fig. 1, usually designated as initial, second and final stages. For highly stressed specimens initial creep, OS, is characterized by a high but

rapidly decreasing creep rate; second stage creep, *SF*, by a constant rate indicated by a straight line and final stage creep, *FA*, by a rapidly increasing creep rate continuing until failure. For intermediate and low stress, Fig. 1, the initial stage begins at a lower deformation value. This is a result of annealing and strain hardening forces. Second stage creep in both low and intermediate loading continues beyond the limit of the graph without evidence that final stage creep is being approached.

Creep Test Procedure

Music wire and Type 304 stainless steel spring wire were selected for the test spring materials: music wire for its wide use at normal temperatures for highly stressed mechanical springs; Type 304 because of its ability to withstand the effects of moderately elevated temperatures. Table I gives mechanical properties and design data of the spring materials.

The springs were cold formed on an automatic coiling machine with the end turns coiled solid; coil set in the wire was not removed. All length tolerances were on the plus side. After forming, the music wire springs were given a thermal treatment at 500 F for one hour; the stainless steel parts at 750 F. Spring ends were ground perpendicular to the axis and small presetting was applied, if needed, to bring the length within the specified free length tolerance.

A schematic drawing, Fig. 2, shows the test setup and the manner of making the creep measurements. To obtain a continuous record of temperature, a centrally located thermocouple is used. Two additional thermocouples are used for checking temperature distribution in the furnace.

Relative displacement between the upper end of the load rod and the upper jig frame is measured by means of a dial gage graduated in 0.001 in. increments. After temperature stabilization is achieved initial readings are made, the load is applied and a second reading taken. The difference between the second and subsequent readings is recorded at regular intervals. These measurements represent axial decrease in height of the spring in inches caused by the creep of the material.

Both the music wire and stainless steel springs are tested at various temperatures and stresses. Wahl correction factor for curvature is not included in calculating the stresses. This factor is considered negligible because, (1) spring index is large, (2) percentage of wire section under concentrated stress is small, and (3) full section of the wire twists under load.

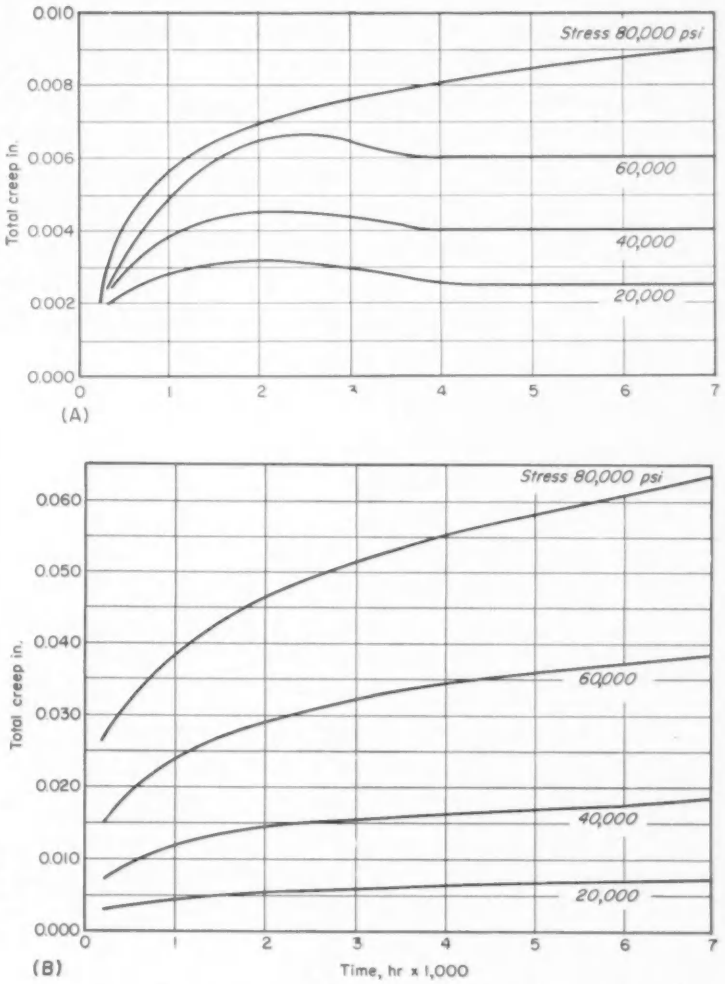


Fig. 3—Total creep against time, (A) for 20 C; (B) for 150 C. Results of tests of music wire helical coil springs.

Creep Test Results

The test results are recorded in terms of decrease in axial length of the spring in inches for continuous increments of time totalling 7,000 hours. The creep-time curves, Figs. 3 and 4, illustrate the over-all effect of temperature, stress and time upon the load carrying capacity of the springs.

From a study of the curves, Figs. 3 and 4, the following observations can be made:

1. Curves for each material have similarities for each of the temperatures and stresses used.

2. Creep-time curves for the higher temperatures and stresses resemble curves obtained with standard tension creep test specimens.

3. All curves exhibit both first and second stage creep. No evidence of final stage creep was observed. First stage creep is largely confined to the first thousand hours of testing.

4. As stress increases, the transition from first to second stage takes place at higher creep levels.

5. For lower temperatures, the ap-

parent creep-time relationship is somewhat complicated by effects not apparent at higher temperatures and stresses. The first stage portions of these curves are roughly similar to those for the higher temperatures and stresses, but after approximately 1000 to 3000 hours of testing, creep proceeds negatively for a short time. Finally, before the end of the tests at 7000 hours, the curves level out to a zero creep rate.

The negative creep rate is believed to be the result of an aging phenomenon with strain aging playing the dominant part. This aging reaction is a trend towards equilibrium, constitutional or mechanical, and away from an unstable condition such as set up by cold plastic deformation. Strain aging accelerates as temperature is increased and is usually accompanied by a slight increase in density and/or modulus, either or both of which could result in apparent negative creep. The magnitude of observed negative creep is very small and for most applications can be neglected.

6. For the higher temperatures and stresses, the portions of the curves in the second stage area systematically exhibit a downward curvature approaching but not reaching zero creep rate, as distinguished from the straight line relationship for the corresponding segment, Fig. 1, of the tension specimen curve. This is of prime importance because curvature here prevents linear extrapolation of the curves for periods of time beyond the duration of the test.

7. At room temperature the creep of music wire springs and Type 304 stainless steel springs is about the same, but at 150 C, the creep of music wire is considerably greater than that of Type 304. At 250 C the stainless springs show fair creep resistance; preliminary tests on music wire at this temperature have shown it to be unsuitable for service.

Creep-Stress Relations

Tension tests establish that creep is approximately an exponential function of stress. To determine if a similar relationship exists for helical compression springs, total creep in inches at the end of 7000 hours is plotted Fig. 5, on logarithmic coordinates. The approximately straight line indicates that the nature of the relationship is exponential.

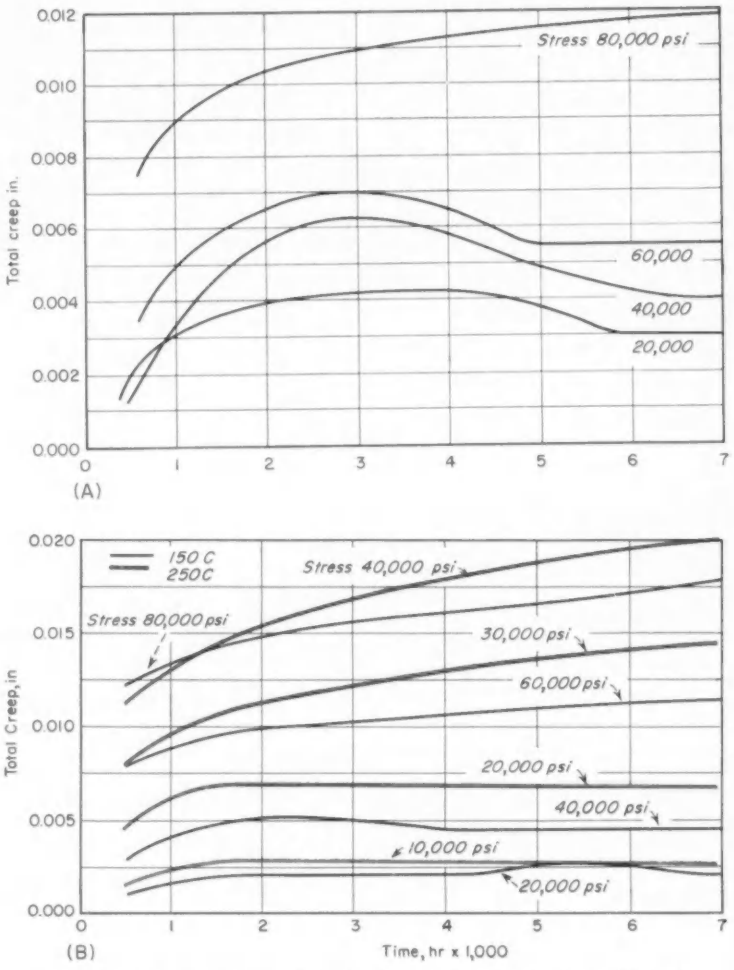


Fig. 4—Total creep against time, (A) for 20 C; (B) for 150 and 250 C. Results of tests of Type 304 stainless steel helical coil springs.

Table I—Creep Test Springs

	Type 304 Stainless	Music Wire
Composition		
Carbon, per cent	0.05	0.92
Chromium, per cent	18.40	....
Nickel, per cent	8.9	....
Design Data		
Wire dia., in	0.050	0.048
Mean spring dia., in	0.388	0.382
Free height, in	1.75	1.75
Total turns	8.5	8.5
Active turns	6.7	6.7
STRUCTURAL PROPERTIES		
Proportional limit, psi	108,200	172,000
Johnsons Elastic Limit, psi	205,800	224,900
Yield Strength		
0.1 per cent offset, psi	198,300	261,500
0.2 per cent offset, psi	235,600	286,500
Tensile Strength, psi	277,200	331,000
Elongation in 8 in., per cent	1.97	2.70
Hardness, RC	49–50	54–55

The decreasing creep rate, exhibited by the second stage creep portions of the creep-time curves for the higher temperatures and stresses, suggests an exponential relationship, which may be valid for time as well as stress. To confirm this, data taken from the second stage portions of the curves for each of the two materials tested at 150 C and 80,000 psi stress are plotted, Fig. 6, on logarithmic coordinates. The linear character of these curves shows that second stage creep is approximately an exponential function of time and thus extrapolation is possible for longer time intervals.

In applying conventional tension creep data to design problems, it is customary to express creep as a percentage of the original gage length. It is impossible to express creep of springs in this form, therefore, the interpretation must be a comparative one. The method chosen is that of comparing ratios of creep to elastic deflection for a test spring and the spring in question. Both creep and elastic deflection, being of the same denomination—inches—can be written as a true ratio. Elastic deflection differs from the standard tension specimen gage length in that gage length is a constant; the elastic deflection of the spring is constant only for that particular stress and the set of creep conditions to which it is subjected.

To illustrate this method of calculation, consider the example of the music wire springs tested at 150 C under 80,000 psi stress for 7000 hours of testing Fig. 3. Under the above conditions creep C is 0.0641 in.; the elastic deflection ED, is 0.4375 in.; the ratio of creep to elastic deflection, C/ED is thus, 0.1465, or 14.65 per cent of the elastic deflection of the spring under test.

The C/ED ratio was calculated for other increments of time and the results, are shown in Fig. 7. Except where negative creep was noted at the lower temperatures and stresses, these curves are linear, making it possible to extrapolate beyond the 7000 hour time limit of the tests.

The advantage of expressing creep as a C/ED ratio is that with the exception of wire diameter, the effects of all basic parameters, including coil diameter and number of turns are cancelled since they are included when C/ED is evaluated. This supplies a basis for comparing test springs to springs of different sizes and designs.

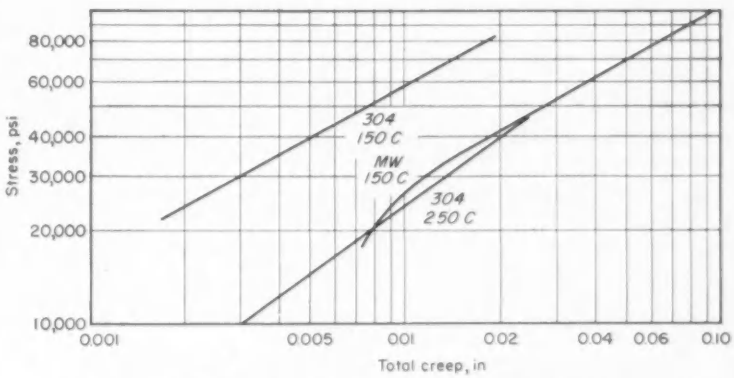


Fig. 5—Stress against total creep at 7000 hours. Logarithmic plot, at higher temperatures and stresses, illustrates the exponential nature of the creep-stress relationship.

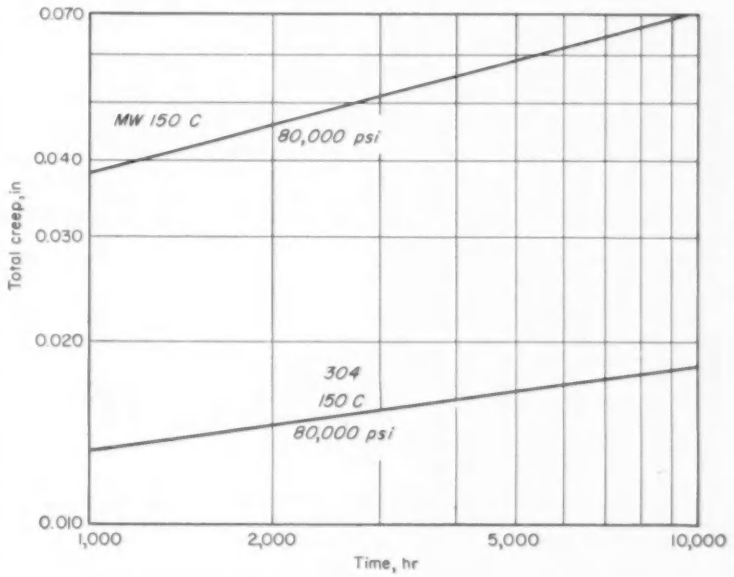


Fig. 6—Total creep against time at 80,000 psi. Logarithmic plot, from second stage creep portions of test curves, illustrates the exponential character of the creep-time relationship.

To illustrate this method of comparison consider further the example of the music wire spring. Assume that, during the testing, there is included another music wire spring, X, duplicating the test spring, but having coil diameter and/or number of active turns varied. Since both springs are subjected to the same stress, both the creep and elastic deflection of each spring will be functions of the same stress. In the previous example, the creep for the test spring at 80,000 psi and 7000 hours is found to be 14.65 per cent of the elastic deflection. Then the creep for spring X, under the same conditions, should be 14.65 per cent of its elastic deflection, even though the numerical values for C and ED for spring X may differ widely from the test spring. Then for spring X, $C/ED = 0.1465$, or $C = 0.1465ED$. The ED for spring X is a known quantity, either by actual measurement or by calculation from the spring formula. Approximate creep value for any spring X for any increment of time can be calculated by referring, Fig. 7, to the appropriate curve for the data needed.

The data supplied, Fig. 7, can be

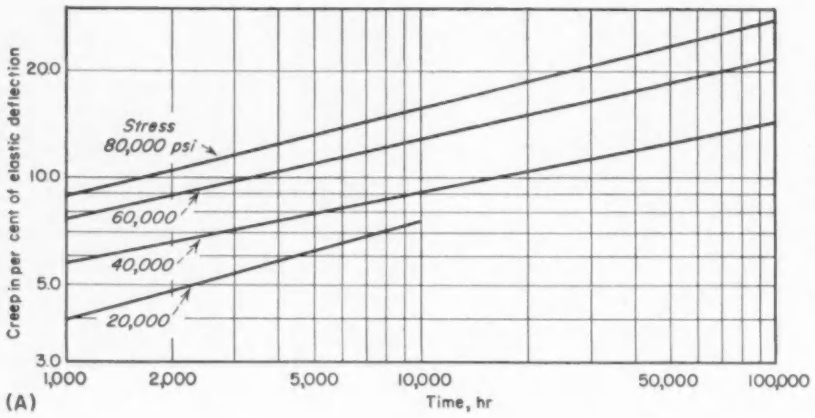


Fig. 7—Creep expressed as a percentage of elastic deflection against time. (A) for music wire at 150 C; (B) for Type 304 steel at 150 and 250 C. Logarithmic plot at higher temperatures and stresses illustrates the linear nature of the curves permitting extrapolation over increased periods of time for creep to elastic deflection ratio.

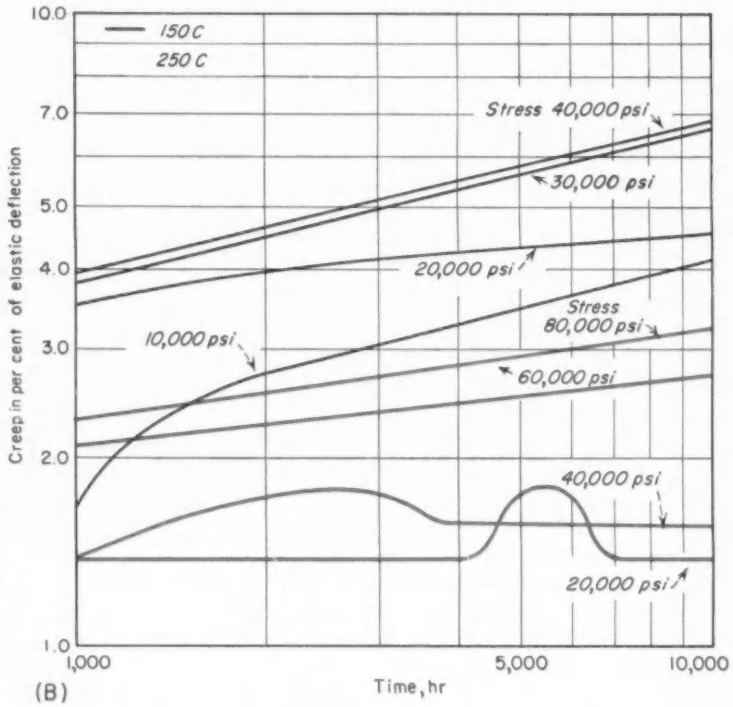
used for wire diameter up to that of the test springs. Since wire strength is inversely, but not linearly, proportional to diameter a safety factor must be used for larger diameters. Additional investigation is needed to determine the required safety factors.

EDITOR'S NOTE—*Product Engineering* and the *Design Digest Issue* have presented other articles on spring and spring material testing useful in working with spring problems.

Numerous methods for testing springs are outlined in "17 Ways of Testing Springs," by C. J. McClintock, February 1956 page 174. The author illustrates test set-ups for evaluating springs of various types.

Materials used in springs are evaluated in "Fatigue Characteristics of Spring Materials," by F. P. Zimmerli and W. P. Wood, *1956 Design Digest Issue*, page F10. Properties of various materials used in springs are compared at different loads and temperatures.

For other articles summarizing properties of spring materials, see also the Editor's Note on page 193, August 1956.



Colored Finishes for Copper

COPPER IS THE ONLY METAL (except gold) having a rich natural color; all other metals are some shade of gray. Also, natural finishes on copper and copper-base alloys offer an unusual range of attractive surfaces, either in the metal itself or through mechanical or chemical treatment.

An 8-page special insert in full color in the December issue will discuss and illustrate these natural finishes, the effect of alloy content and coloring treatment and mill produced surfaces. The article, authored by A. L. Heim, research engineer of Copper & Brass Research Association, will include specifications for a variety of coloring and surface treatment procedures.

Typical examples will be shown in natural color with detailed data on finishing systems used for each. Other illustrations in full color will show color effects obtained by surface conversion treatment on 60-40 brass, and dark finishes on 85-15 brass, all with formulas and specifications. Mill produced surfaces and special embossing effects are shown, along with suggestions on tumbling, ball burnishing, bright dipping, electrolytic polishing, grinding and polishing.

Effect of fabricating method on natural color is also discussed, with suggested compositions for color matching of assembled parts produced by different methods.

Table I—Properties of Protective Metal Coatings for Aluminum and Copper

Coating or Base Metal	Resistivity, Microhms per cm³	Relative Hardness	Max. Operating Temp, F	Melting Point, F	Galvanic Action P—Protects A—Attacks		Galvanic Potential, volts		Appearance, A—Excellent B—Good C—Fair D—Poor		Approx. Plating Cost, cents per sq ft	
					Copper	Aluminum	From Copper	From Aluminum	Initial	Aged	On Copper	On Aluminum
ELECTROPLATED												
Cadmium	6.83	2.0	300-400	610	P	A	+0.75	−1.27	A	A	6	48
Nickel	6.84	7.0	Above 400	2651	P	A	+0.60	−1.42	C	C	7	50
Silver	1.59	2.7	300-400	1761	A	A	−0.46	−2.47	A	D	17	65
Tin	11.5	1.8	200-300	450	P	A	+0.48	−1.53	B	B	7	50
Zinc	5.92	2.5	100-200	788	P	A	+1.11	−0.91	A	B	4	40
HOT DIP												
Tin-Lead	17.5	1.6	300	360	P	A	+0.47	−1.54	A	A	8	60
UNCOATED METAL												
Copper	1.68	3.0	200	1981	—	A	—	−2.02	A	D	—	—
Aluminum	2.66	2.9	Above 400	1220	P	—	+2.02	—	A	A	—	—

Metal Coatings . . .

for Electrical Connections

Protective metal platings and coatings for aluminum and copper electrical contact surfaces; required coating properties, and evaluation of metals used.

HOWARD B. GIBSON,
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BOTH ALUMINUM AND COPPER SURFACES, unless thoroughly cleaned of high-resistance surface films, will function inefficiently under heavy currents and can eventually fail due to progressive overheating. These high resistance films can be formed under bolted aluminum or copper contacts by oxygen or corrosive media penetrating between the metals in contact. To protect against such failure or against increased contact resistance, protective coatings are used. Previous article, "Protective Coatings for Electrical Connections", April 1955 page 156, illustrated the destructive effects of high-resistance films and discussed the use of non-metallic coatings such as resins and waxes to protect these contact surfaces. Metallic films can also function as corrosion barriers against atmospheric attack or against galvanic corrosion of dissimilar metals in contact with an electrolyte.

TYPES OF COATINGS

The most commonly used metal coatings for aluminum or copper electrical contacts are listed in Table I. Cadmium, nickel, silver, tin, and zinc are applied by plating. The hot-tin coating is applied by dipping the connector into a tin-lead solder bath.

The process for plating aluminum requires the applica-

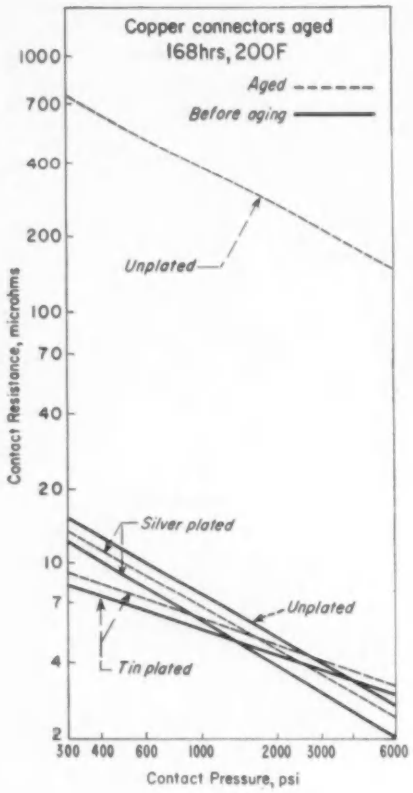


Fig. 1—Effectiveness of silver and tin plating in preventing formation of high-resistance oxide films. Contact resistance of bare copper and aluminum is shown when samples were cleaned and then after aging; when platings were used, low contact resistance of both materials was retained despite aging.

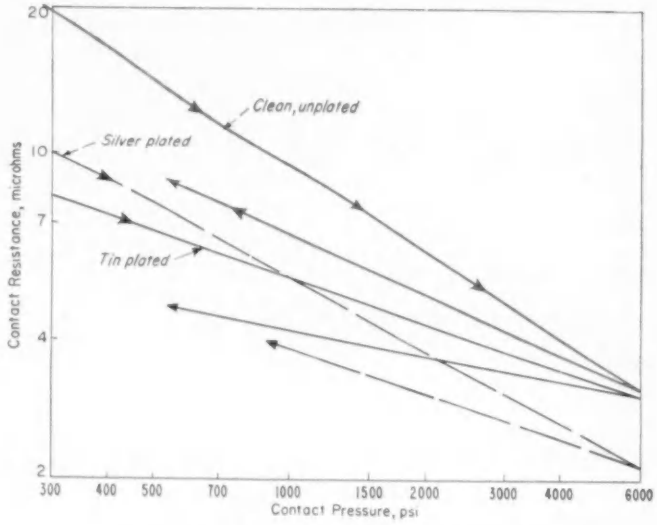


Fig. 2—Effect of soft coatings on contact resistance. Tin is softer plating than silver and produces lower contact resistance than silver at lower contact pressures. At higher contact pressures superior conductivity of silver is effective in reducing resistance below that of tin.

tion of zinc film to the base metal by immersion; a layer of copper is electrodeposited over the thin zinc layer to form the base for application of the individual coatings evaluated here. For copper, the coatings are applied directly to the surface.

Coating Properties

For metal coatings to exhibit better electrical contact and other properties than either base aluminum or copper, certain characteristics are required:

Resistance to Oxidation. The metal film must resist forming high-resistance oxide films at temperatures of 80 C or higher. Films which do form should be easily broken or penetrated under pressure.

Coating Hardness. The coating must be soft enough to flow under relatively low contact pressures; this results in greater contact areas for given pressure than for the bare metal on which the coating is used.

Contact Resistance. The coating must exhibit low electricitcal contact resistance at low contact pressures. This resistance should remain low despite aging in oxidizing atmospheres.

Compatibility. The coating must be compatible with base metals an other contact metals or materials. The coating should not react with ordinary contact metals in either dry or moist atmospheres. The coatings should not be effected by various types of grease-base electrical joint compounds which are frequently used to protect contact joints from oxygen or moisture penetration.

Application. Application of the coating must not require any special equipment other than commercial electroplating equipment.

Galvanic Corrosion Resistance. It is desirable that the electropotential difference between the metal coating and either aluminum or copper should be small in ordinary electrolytes. This tends to lessen galvanic corrosion of either contact member in moist locations.

Appearance. Where customer acceptability is a factor, the coating should present a pleasing surface.

Cost. Platinum, gold, iridium, and other precious metals used in make-and-break contacts are not considered here because of relatively high cost. These metals offer little advantage for stationary contacts operating at normal voltages.

Measuring Performance

To determine the value of various metal coatings in producing and maintaining low-resistance contact surfaces specimens consisting of thin, smooth 1-in. bars of aluminum and copper were chemically cleaned of surface films and plated or coated. Specimens were then aged at varying temperatures and in a salt fog atmosphere. For comparison, similar bars were chemically cleaned and subjected to the same tests without coatings.

Test groups of bars were placed in stackups in a testing machine. The resistance of test groups of bars was determined at contact pressures from 300 to 6000 psi. The test set-up and electrical test connections were the same as

Table II—Effect of Plating Thickness and Aging on Contact Resistance

Coating or Base Metal	Plating Thickness, mils	Contact Resistance at 6000 psi, microhms				
		Initial	Aging Time and Exposure Conditions			
			300 hr			100 hr
			200 F	300 F	400 F	Salt Fog
ELECTROPLATED						
Cadmium	0.70 0.35	3.5 5.25	3.5 5.45	8.5 5.4	9.9 7.5	100 80
Nickel	0.2 0.4	1.15 2.055	1.00 2.00	1.55 2.35	4.1 4.0	7.5 4.5
Silver	0.2 0.5	1.75 1.50	2.25 1.45	2.75 7.45	1,000 21.4	1,000 70
Tin	0.2 0.5	1.45 2.45	1.50 2.40	2.75 2.80	4,000 80.0	2.90 7.50
Zinc	0.17 0.35	5.0 5.5	12.0 9.5	77.0 35.0	600 251	1,000 335
HOT DIP						
Tin-lead	0.8 1.0	2.70 2.85	2.75 2.85	2.75 2.70	60.0 20.0	3.50 4.21
UNCOATED METALS						
Copper	—	16	175	240	20,000	320
Aluminum	—	40	60	80	200	480

shown in the earlier article referred to above.

Table II gives the contact resistances of coated and uncoated bars at the beginning of the tests and after 300 hr aging at 200, 300 and 400 F, and also in a salt fog atmosphere at normal ambient temperature. Protective coatings of tin, zinc, cadmium, silver, nickel and tin-lead (solder) all maintained contact resistance substantially below that of the unprotected copper or aluminum. As an example, Fig. 1 shows the contact resistance of coated copper bars as compared to bare stock aged for 168 hr. at 200F. The resistance of clean copper before aging is also included for comparison.

Relative value of various coatings in preventing high-resistance films from forming is indicated in Table I. Nickel provides the best protection at elevated temperatures, zinc provides the poorest. Tin, silver, and tin-lead show varying degrees of protection up to 300 F. All samples gradually darkened when subjected to higher temperatures. The nickel coating formed a haze at 200 F, the tin-lead remained bright to 400 F.

Ability of the coatings to resist salt fog corrosion varies with film thickness. This variation is believed to be a direct function of film porosity. The poor corrosion performance of zinc is believed to be caused by a formation of a high-resistance film in the salt atmosphere.

General cost comparisons in the table are on the basis of barrel plating for copper and still plating for aluminum. Hot tin costs are based on hand dipping.

Relative degree of galvanic corrosion of dissimilar coatings in contact with each other or with aluminum or copper is indicated by the potential difference in volts listed in Table I. The letter *P* in the "Galvanic Action" columns indicated the base metal is protected and the coating sacrificed. The letter **A** denotes that the base metal will be attacked and coating material protected. As an example, electrolytic coupling of tin to aluminum results in an electropotential of 2.47 volts. The higher potential difference indicates that the aluminum will be sacrificed at a greater rate. Coupling tin to copper creates a potential of 0.48 volts and sacrifices the tin to protect the copper.

Hardness of the coating has a significant effect on contact resistance, as shown in Fig. 2. The conductivity of tin is only 15 per cent that of copper, while silver is 110 per cent of copper, but at low contact pressures resistance of the tin coating is lower than that of silver. This is caused by the greater contact area of the softer tin at the lower contact pressure. At higher pressures contact area of the silver-plated bar increases, and final contact resistance is lower than that of the tin-coated bar. This effect is even more pronounced in the tin-lead solder coating which exhibits adhesion under test pressures.

EDITOR'S NOTE—The previous article mentioned, "Protective Coatings for Electrical Connections", April 1955 page 156, described and evaluated various types of non-metallic coatings used to prevent surface oxidation or corrosion of aluminum and copper connections. "Compression Terminals for Aluminum Conductors", September 1954 page 150, discusses use of a compound of metal power suspended in petrolatum in providing surface-film cleaning and protection against film reformation for aluminum-to-aluminum and aluminum-to-copper connections.

Table I—Steps Required for Preparation of Hydraulic System When Changing to Aqueous Base Fire-Resistant Fluid

1. Completely drain system of previous fluid:
   - Reservoir
   - Accumulator
   - Coolers
   - Lines
   - Cylinders
2. Disconnect and remove filters and intake pipe strainers.
3. Wipe reservoir dry with lint-free rags. If there is paint on inside surface, remove by commercial paint remover or hot caustic.
4. Reconnect system; clean and reinstall intake strainers.
5. If petroleum oil was previously used—
   - (a) Fill machine with light hydraulic oil
   - (b) Operate machine for 20 min
   - (c) Pump out sump; drain all accumulators, cylinders and coolers.
   - (d) Wipe reservoir clean.
6. Fill with fire-resistant fluid—including accumulator.
7. Install filter.
8. Cycle machine for 10 min.
9. Check reservoir level; if low, fill to level.
10. Check all piping for leaks, and tighten if necessary.
11. Attach "Caution" tag to the fill pipe.

If Aqueous Base Type is Replacing Another Type of Fire-Resistant Fluid—Note These Further Precautions:

1. After careful draining, fill machine with a warm water solution (100-1) of flushing concentrate recommended by the supplier.
2. Set pressure control valve at 50-75 psi.
3. Cycle machine for 20 min.
4. Drain and wipe clean.
5. Clean intake strainers and reinstall.
6. Reset pressure control valve to normal setting.
7. Check pump for previous wear.

If Phosphate Base Fluid is Replacing Hydraulic Oil

All residual petroleum oil must be thoroughly removed; otherwise it will be dissolved in the ester and lower the fire resistance.

1. Drain system as specified.
2. Clean reservoirs as specified.
3. Blow lines clear with dry low-pressure air.
4. Pump bodies and large valve bodies should be opened and swabbed dry by hand.
5. If bladder-type accumulators are used replace bladders with butyl rubber type.
6. All low points in piping system must be opened and drained.
7. All filters and strainers must be removed and cleaned.
8. All paint must be removed from internal surfaces.
9. Replace leaking seals; install special dynamic seals if type now used is affected by fluid.
10. Reassemble and connect components.
11. Fill system with phosphate ester fluid.

Changing Over to Fire-Safe

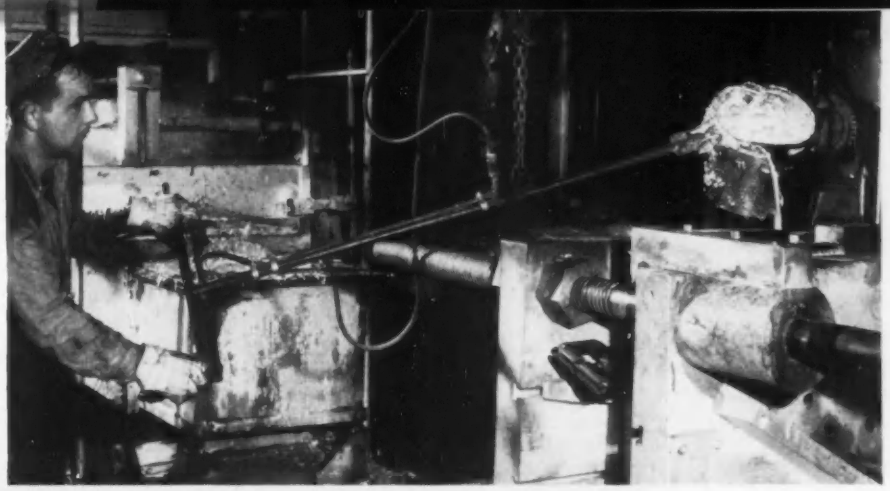
Satisfactory operation of fire-resistant fluids is dependent on careful system preparation. Here are detailed change-over recommendations on system cleanliness, filtration, pump design and flow characteristics.

INCREASING APPLICATION OF FIRE RESISTANT FLUIDS in hydraulic systems has resulted in a better understanding of their service characteristics and the preparations required in the change-over from a petroleum oil. Problems can generally be traced to two causes: incomplete preparation of equipment prior to change-over; and mechanical deficiencies in the system, such as inadequate pump porting.

Certain precautions are common to both aqueous and non-aqueous fluids. Table I includes these plus the special considerations necessary for each type of fluid.

Paint Removal

It is important to remove any oil resistant paint that would come in contact with the replacement fluid. Fire resistant fluids tend to soften and peel off paint which may later enter the hydraulic circuit and interfere with operation. Paint removal is fre-



(ABOVE) A permanent mold machine in which the mold is held closed by hydraulic pressure. Molten aluminum is the fire hazard and a water-base fluid has functioned without trouble for 16 to 24 hours a day over a period of 1½ years in this machine.

(LEFT) Hydraulic welding jig for holding assemblies in place while welding. Fire resistant fluid is used because of possible arcing between rod and hydraulic piping lines on the welding jig.

Hydraulic Fluids

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Manager, Lubrication Department
E. F. Houghton & Co.

quently difficult and time-consuming. It is often necessary to resort to hand scraping following application of a commercially available paint remover.

Caustic fluids, when mixed with hot water, may also be used to attack and remove paint. If steam is permitted to bubble into the caustic until the reservoir is filled, good circulation is obtained and the solution is kept hot making it much more efficient and active. Normally paint will have been loosened after this treatment and can be drained with the fluid. The reservoir is then filled with water and rinsed thoroughly with enough changes of fluid until no trace of alkalinity (litmus paper test) can be observed.

Certain commercially available paints will resist water-base fire-resistant fluids. Epon base, saran base or rubber base paints are usually preferred. Plastic sealing compounds are also available which are impervious to the hydraulic fluid.

Oil Elimination

Oil is soluble in a phosphate ester and more than about 1 per cent residue of oil could impair its fire resistant qualities. For this reason it is necessary to drain and, if possible, blow out all traces of oil from the various parts of the system. Hand wiping of the reservoir is essential. Low spots including valves, elbows and accumulators should be broken, cleaned and drained individually.

Where the systems are so complex and inaccessible that actual draining and hand wiping are not possible, the phosphate fluid can be used as a flushing medium. The new fluid should be allowed to circulate for sev-

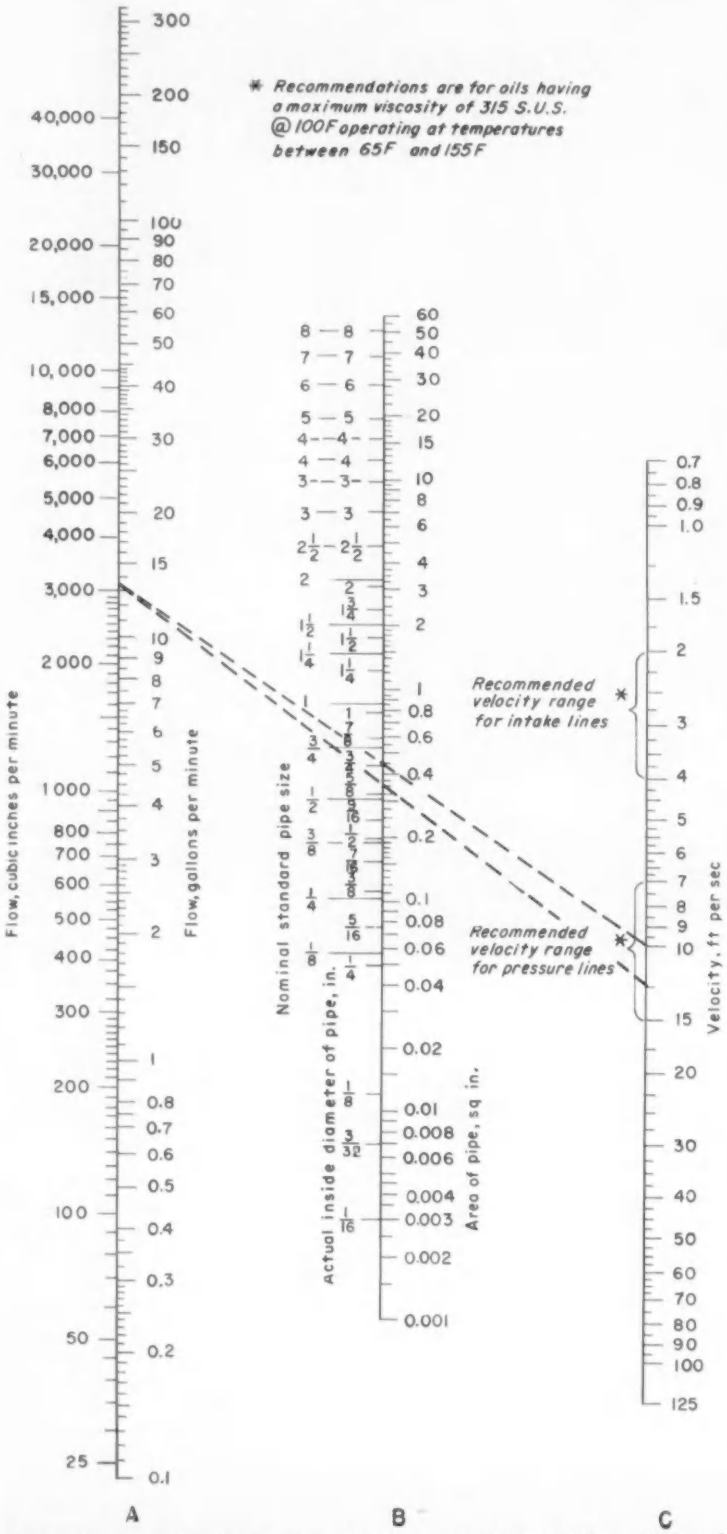

* Recommendations are for oils having a maximum viscosity of 315 S.U.S. @ 100F operating at temperatures between 65F and 155F
Flow, cubic inches per minute
Flow, gallons per minute
Nominal standard pipe size
Actual inside diameter of pipe, in.
Area of pipe, sq in.
Velocity, ft per sec
Recommended velocity range for intake lines
Recommended velocity range for pressure lines
A
B
C

Fig. 1—Nomogram for determination of pipe size as a function of flow volume and velocity. *Courtesy Vickers Inc.*

eral hours until it is hot enough to do a good job of cleaning. Paint will also be loosened and most of it can be readily removed. If it is impossible to get at the reservoir to remove the paint, this flush of the phosphate material must be continued until the paint peels off and is carried to the filters. Fluid used for flushing can be drained and stored for similar use in other machines.

Even meticulous flushing and wiping of reservoirs will leave small amounts of oil in a hydraulic system. In time, this residue will collect as an oil film on the surface of a reservoir filled with fire resistant fluid. Trapped air and gas bubbles will not be able to escape, endangering pump performance. Regular skimming of the reservoir fluid, especially immediately following change-over to a fire resistant fluid is an important maintenance practice.

Seals and Packings

Non-aqueous fluids will have a deleterious effect on packings compatible with hydraulic oil. Static seals will swell, although this may not be troublesome since they simply tighten up in the aperture. However, if portions of the system containing these seals are later dismantled the seals must be replaced with new seals compatible with non-aqueous fluids.

Dynamic seals, when swollen, tighten and rub on moving parts resulting in premature wear and possible failure. It is therefore advisable to replace dynamic seals with compatible types at the time of change-over.

Accumulators using a rubber bladder to separate the gas from the fluid will require a change to butyl rubber at the time of the conversion.

Water-base (glycol thickened) fluids do not adversely affect standard seals used with petroleum oil. In a few pumps, gaskets of rubber impregnated with cork are used and should be replaced with rubber products designed for this purpose.

Strainers

Intake strainers are usually in the form of a screen of varying mesh sizes wrapped around a cylinder. To insure good intake conditions a mesh of 60 or less should be used since smaller meshes interfere with easy

flow into the pump.

When handling water base fluids these screens should not be coated with either cadmium or zinc (galvanized). Nickel-plated filters are now available at no extra cost and magnetic plug assemblies have been successfully employed in the reservoir to trap abrasive ferrous particles that would pass through the coarser filter screens and wear the pump ring.

Temperature Control

Reservoir temperatures above 130 F tend to dissipate the water in water base fluids too rapidly requiring frequent make-up. Viscosity of synthetic fluids drops at these temperatures and so heat exchangers are recommended for both fluids for control of sump temperatures within proper limits.

Flow Considerations

All fire resistant fluids presently available are higher in specific gravity than their petroleum oil counterparts. Pumps designed for lighter fluids may be inadequately ported for a heavier fluid. What were formerly believed to be wear failures resulting from poor fluid lubricity are now suspected to be caused by unsatisfactory fluid flow within the pumps. Some pumps are being redesigned to permit streamlined flow at all pressures.

Intake flow is particularly sensitive to pressure drops because it is dependent on the force of atmospheric pressure. Minimum piping between reservoir and pump intake is essential and the reservoir fluid level should be kept as high (relative to the pump intake) as possible.

One large pump manufacturer recommends that pressure in the suction line adjacent to pump inlet port should never drop below 12 psia. If pressure is only slightly below this value, larger size pipe into the intake may help. If all else fails, pump speed should be reduced to establish a lower displacement flow. These precautions are necessary to avoid the possibility of cavitation or pump starvation. Charts have been devised, as shown in Fig. 1, to determine the sizes of pipe in hydraulic circuits when pump flow output and flow velocity are known or selected.

Compressibility of fire resistant fluids is lower than that of petroleum oils. Reduced shock absorbing characteristics of the fluid may have to be compensated by lengths of flexible hose in strategic parts of the piping layout or careful valve design to establish controlled acceleration and deceleration.

Pumps

Before fire resistant fluids are installed pumps should be examined carefully to make certain that the sealing elements are proper and of a design that prohibits air leakage. Entry of air will cause vibrations inside the pump, resulting in premature wear and lower pump life.

When a water-base fluid is being installed, the previous pump lubricant may be inappropriate. If grease is applied through a fitting, the soda-base type should be replaced by a water-resistant grease or mixed base type. Leakage of hydraulic fluid past shaft seal and into bearing will emulsify a soda-base grease. Tests conducted on compatibility of greases with fluids have shown that aluminum, calcium and lithium base greases work well with water base fluids.

Water Content and Fluid Testing

As with petroleum hydraulic fluids, it is often necessary to take samples of used fluid from the reservoirs of equipment and have them checked periodically to make certain that no contamination has occurred. This will be evidenced by lack of change in the physical and the chemical properties.

It is often necessary to replenish the water content of water base fluids depleted in varying degrees according to temperature of operation and design of equipment. In well designed hydraulic systems, temperatures can be controlled to conform with recommendations made by the

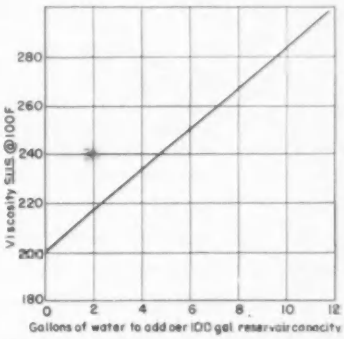


Fig. 2—Typical water make-up chart to determine the additional water required to replenish a depleted water-base fluid and bring its viscosity to 200 universal seconds.

JIC (Joint Industries Conference) at less than 130 F. At these temperatures and when the only chance for the escape of vapor is through the air breather, water evaporation from the tank is low. Loss of water is indicated by an increase in viscosity and, according to charts furnished by the marketer of the fluid, distilled or boiler feed (deionized) water is added as required. Fig. 2 is a typical example of this kind of chart.

Chemical decomposition of water-base fluids brought about by contamination or malfunctioning of the hydraulic system, high temperatures, etc. can be determined by measurement of the pH. The pH limits can be obtained from the fluid marketer and any pH lying outside these limits will require remedial action, ordinarily a complete drain and refill of the system. Determination of pH can be made in the user's plant by means of Hydrion papers, available from a chemical supply house. Consultation with fluid marketers on the proper procedure in the use of Hydrion papers is essential.

Water-base fluids should never be used in magnesium die-casting ma-

Table II—Analysis of Used Hydraulic Fluid

Installed in	Conversion Date	Last Sample Taken	Service Period	pH	Visc.	Depletion
Mach. #2173	June, 1954	March, 1956	21 mos.	8.1	207	None
Mach. #2247	June, 1954	Jan. 1956	19 mos.	8.0	199	None
Mach. #1748	June, 1954	Oct., 1955	16 mos.	8.1	196	None
Mach. #1920	June, 1954	Oct., 1955	16 mos.	8.2	209	None
Mach. #1392	June, 1954	June, 1955	12 mos.	8.3	199	None
Mach. #1415	June, 1954	June, 1955	12 mos.	8.1	192	None
Mach. #2046	June, 1954	Sept., 1955	15 mos.	8.2	205	None

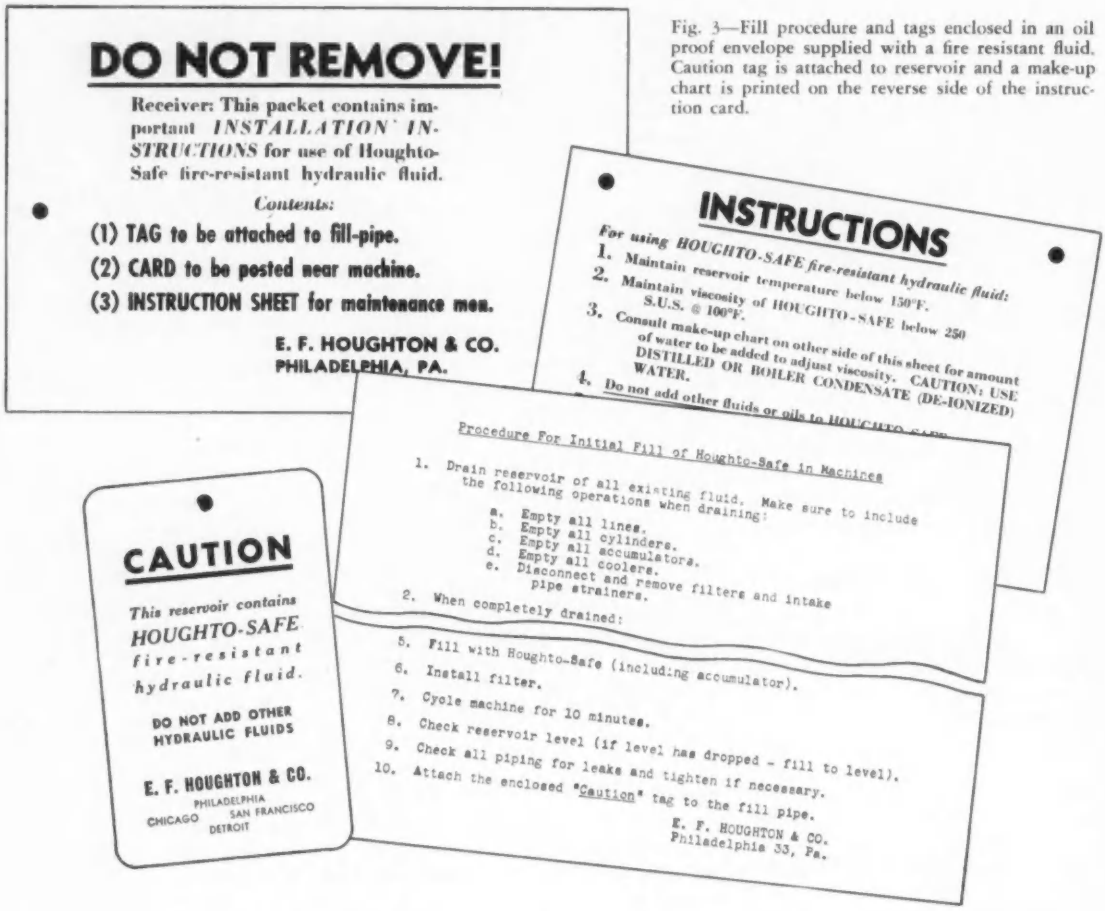

DO NOT REMOVE!
Receiver: This packet contains important INSTALLATION INSTRUCTIONS for use of Houghto-Safe fire-resistant hydraulic fluid.
Contents:
(1) TAG to be attached to fill-pipe.
(2) CARD to be posted near machine.
(3) INSTRUCTION SHEET for maintenance men.
E. F. HOUGHTON & CO.
PHILADELPHIA, PA.
INSTRUCTIONS
For using HOUGHTO-SAFE fire-resistant hydraulic fluid:
1. Maintain reservoir temperature below 150°F.
2. Maintain viscosity of HOUGHTO-SAFE below 250 S.U.S. @ 100°F.
3. Consult make-up chart on other side of this sheet for amount of water to be added to adjust viscosity. CAUTION: USE DISTILLED OR BOILER CONDENSATE (DE-IONIZED) WATER.
4. Do not add other fluids or oils to HOUGHTO-SAFE
Procedure For Initial Fill of Houghto-Safe in Machines
1. Drain reservoir of all existing fluid. Make sure to include the following operations when draining:
a. Empty all lines.
b. Empty all cylinders.
c. Empty all accumulators.
d. Empty all coolers.
e. Disconnect and remove filters and intake pipe strainers.
2. When completely drained:
5. Fill with Houghto-Safe (including accumulator).
6. Install filter.
7. Cycle machine for 10 minutes.
8. Check reservoir level (if level has dropped - fill to level).
9. Check all piping for leaks and tighten if necessary.
10. Attach the enclosed "Caution" tag to the fill pipe.
E. F. HOUGHTON & CO.
Philadelphia 33, Pa.
CAUTION
This reservoir contains HOUGHTO-SAFE fire-resistant hydraulic fluid.
DO NOT ADD OTHER HYDRAULIC FLUIDS
E. F. HOUGHTON & CO.
PHILADELPHIA
CHICAGO SAN FRANCISCO
DETROIT

Fig. 3—Fill procedure and tags enclosed in an oil proof envelope supplied with a fire resistant fluid. Caution tag is attached to reservoir and a make-up chart is printed on the reverse side of the instruction card.

chines, nor in the presence of molten magnesium.

Examples of used water-base fluid, are shown in Table II. This installation included over 250 piston-type pumps operating at pressures up to 4,000 psi, for periods varying from one year to two years. Pump troubles occurred in three units, about what would be expected from petroleum oil.

No additive depletion was observed in these samples nor in any from 23 other installations in that group. It is interesting to note that of 119 samples received from the user 97 showed no change in water content. Nine showed a loss of 1 per cent water, seven showed 2 per cent and two a loss of 3 per cent. Only one had a really significant loss of 6 per cent. There was a water increase in two samples, 1 per cent and 2 per cent respectively, indicating water contamination.

Water in moderate amounts, as when brought about by condensation, can be tolerated by water-base fluids. Water of condensation or through contamination will float on top of phosphate ester base fluids and can be removed by skimming.

Petroleum oil mixes poorly with water-base fluids and will usually float on top of the fluid where it can be skimmed off. Oil is completely soluble in phosphate base fluids, and every precaution should be taken to keep oil out of the system. If oil contamination is unavoidably encountered it can be removed from the phosphate fluid by centrifuging. Usually 1 or 2 per cent of oil can be tolerated.

Summary

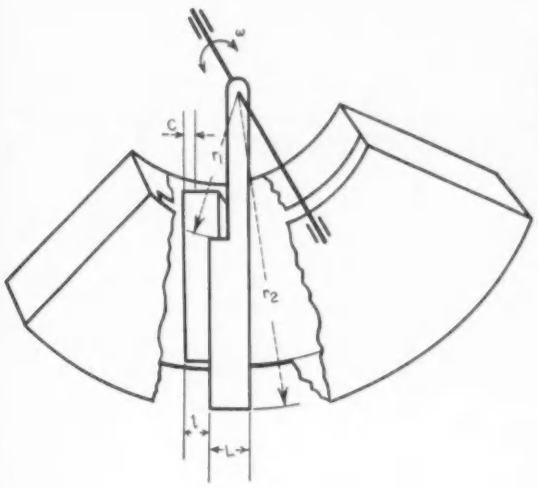
It will be noted from the procedure chart for change-over and preparation for a synthetic fluid that both types of fluids demand careful cleaning of the system before installation. The water-base group is less costly and more tolerant of packings; the synthetic type will withstand higher temperatures and has a better wear-factor than the aqueous in certain types of pumps.

No hard and fast rules can be laid down until all the variables are known. A technical representative of the fluid supplier should be able to make a sound recommendation which the user can safely follow.

EDITOR'S NOTE—Previous articles published in *Product Engineering* covered the characteristics of fire resistant fluids and the factors governing their choice for a particular installation:

"Synthetic Hydraulic Fluids," by J. S. Harris, December 1954, is a detailed discussion of the physical characteristics of the synthetic fluids and how they are determined.

"Designing for Fire Resistant Hydraulic Fluids," by R. Q. Sharpe, August 1956, is a comparison of fire resistant fluids with quality petroleum oils on the basis of fire resistance, viscosity, oxidation, rust resistance, foaming, and effect on sealing materials and paints.



Damping Factor Calculations

Supplementary remarks on the equations given in "Calculating Damping Factors for Dashpot Dampers" in the April 1956 issue.

BOAS J. POPPER
Ministry of Defense, Tel Aviv, Israel

THE PAPER "Calculating Damping Factors for Dashpot Dampers" which appears in the April issue of *Product Engineering*, states rightly that if one calculates the damping factor as accurately as possible, one can largely dispense with the building of models. However, the calculations suggested in the paper are not as complete as appears desirable. The following remarks may supplement the paper.

1. The piston velocity is not always negligible as stated in assumption 2. If one takes into account and rejects the approximation made at the end of page 163, the total pressure difference acting on the piston becomes

$$p = 3\frac{\mu LVD}{C^3}\cdot\frac{1+C^2/3D^2}{1+C/2D} = 3\frac{\mu LVD}{C^3}\cdot\alpha \qquad (18)$$

For some devices (such as hydraulic valves where a small dashpot effect is desired), C/D is not at all small, and in this case α is not unity.

2. The velocity gradient near the piston walls L results in a drag on the piston, which amounts to

$$F_L = \frac{3}{2}\pi\mu LV\left(\frac{D}{C}\right)^2\left(1-\frac{C}{D}\frac{3\alpha-2}{3\alpha}-\frac{2}{3\alpha}\frac{C^2}{D^2}\alpha\right.$$
$$= \frac{3}{2}\pi\mu LV\left(\frac{D}{C}\right)^2\beta\cdot\alpha \qquad (19)$$

3. Since the damping medium which is accelerated to the velocity v has a finite density ρ, it exerts also a drag on the piston amounting to

$$F_{(mv)} = \frac{d}{dt}(mv) \qquad (20)$$

where m is the displaced mass.

Assuming a more or less constant velocity v, the average velocity v may be introduced in Eq (20):

$$v = \frac{1}{C}\int_0^c vd\gamma = \frac{1}{4}VD\left(1-2\frac{C}{D}\right)$$

$$\frac{dm}{dt} = \rho\frac{1}{4}(D-c)^2$$

Then, one has:

$$F_{(mv)} = \frac{1}{16}\pi\rho\frac{D^2}{C}V^2\left(1-4\frac{C}{D}+5\frac{C^2}{D^2}-2\frac{C^3}{D^3}\right)$$
$$= \frac{1}{16}\pi\rho\frac{D^2}{C}V^2\gamma \qquad (21)$$

This force cannot be neglected, especially at high velocities and in mercury dashpots.

The summation of these three factors gives a better approximation for f. Eq (8) of the original article in a corrected form will give:

$$f_{corr.} = \frac{3}{4}\pi\mu L\left(\frac{D}{C}\right)^3\alpha\left(1+2\frac{C}{D}\beta\right)+\frac{\pi}{16}V\rho D^3\frac{1}{C}\gamma \qquad (8)a$$

Considering the first member only, and introducing c/D = 0.15 (Fig. 1), which may be sometimes a practical value, one has

$$f_{corr.} = \frac{3}{4}\pi\mu L\left(\frac{D}{C}\right)\times 1.22$$

whereas f calculated by Eq (8) yields

$$f = \frac{3}{4}\pi\mu L\left(\frac{D}{C}\right)^3\times 1$$

which leads to an error of 22 per cent.

In this connection, another type of rotary dashpot (see accompanying drawing) used mainly in measuring instruments, may be of interest. The advantage of this type lies in its comparatively high damping factor and the possibility to regulate it somewhat by cutting the edges L. Integrating the torque along the edges L and neglecting the influence of bottom and top of the damping leaf, one gets the following expression:

$$f = \frac{T}{W}$$
$$= \frac{2}{3}\mu r_2^2 l'\left[\frac{g}{4}\left(1+\frac{l}{C}\right)^2\left(1+\frac{r_1}{r_2}\right)\left(1-\frac{r_1^2}{r_2^2}\right)+\left(1-\frac{r_1^2}{r_2^2}\right)\right]+$$
$$\frac{1}{32}\omega\rho\frac{r_2^4 l'}{C}\left[\left(1-\frac{r_1^4}{r_2^4}\right)\left(1-\frac{2}{3}\frac{C}{l}+\frac{C^2}{3l^2}\right)+\frac{r_1}{r_2}\left(1-\frac{r_1^2}{r_2^2}\right)\left(2+\frac{4}{3}\frac{C}{l}-\frac{2}{3}\frac{C^2}{l^2}\right)\right]$$

The influence of bottom and top of the leaf should be calculated in accordance with the paper mentioned, and superimposed in Eq (22).

As a conclusion, it would seem advisable to complete if possible the mathematical calculations and to neglect small quantities only after introducing numerical values.

Table I—Tensile Properties of HK31 Alloy Sheet and Plate

(Short-time exposure to temperature)

Form	Temper	Temperature, deg F	Elongation, per cent	Modulus, psi × 10^6	Tensile Strength, psi × 1000	Yield Strength, psi × 1000
Sheet, 0.040–0.250 in.	0	70	23	6.4	33	21
		300	50	6.2	18	15
		400	50	6.0	15	13
		500	34	5.4	13	11
		600	60	4.3	10	7
	H24	70	8	6.4	37	29
		300	20	6.1	26	23
		400	21	5.7	24	21
		500	19	5.2	20	17
		600	70	4.1	13	7
	T6	70	14	6.4	37	21
		300	19	5.9	25	16
		400	19	5.8	23	15
		500	21	5.5	20	14
		600	22	5.4	18	12
	T6 As-welded (0.071 in.)	70 (W)	3.5	....	27	....
		300	....	....	....	....
		400 (HA)	5.0	....	22	....
		500	....	....	....	....
		600 (BM)	14.0	....	19	....
Plate, 0.250 in. and up	H24	70	15	....	31	23
		300	16	....	23	21
		400	16	....	20	18
		500	15	....	18	16
		600	36	....	14	7
	T6	70	13	....	37	18
		300	20	....	28	16
		400	21	....	26	15
		500	18	....	21	14
		600	17	....	19	12
Sheet	2024-T3 Aluminum	70	19	11.0	68	46
		300	15	9.0	57	41
		400	8	8.5	46	40
		500	6	6.5	36	34
		600	12	5.0	16	15

Failure occurred in: (W)—Weld; (HA)—Heat-affected zone; (BM)—Base metal.

Magnesium-Thorium Alloy

A new light alloy with high modulus-to-weight ratio for use in the 500-700 F range. Mechanical properties, heat treatment, forming and welding technique, corrosion treatment.

MATERIALS AVAILABLE for frame and panel applications in the temperature range 500-700 F are limited. Where thicker sections are required for stiffness against buckling, the lightest material for a given volume holds the advantage. Until recently, the only alternatives to aluminum have been steel alloys. Although these alloys have good strength-weight ratios, excessive weight is required to provide stiffness. This is because critical buckling loads in panel members are proportional to Young's modulus and the cube of skin thickness. Hence materials of higher modulus-weight ratio become more important.

A light material recently developed and now in production possesses useful properties at moderately elevated temperatures. Designated HK31, this material is a magnesium alloy containing 3 per cent thorium and 0.75 per cent zirconium. With a density one-quarter that of steel, this alloy retains high strength and elastic modulus to temperatures over 600 F, has good creep resistance, can be cast, heat-treated and welded, and is available in sheet and plate form.

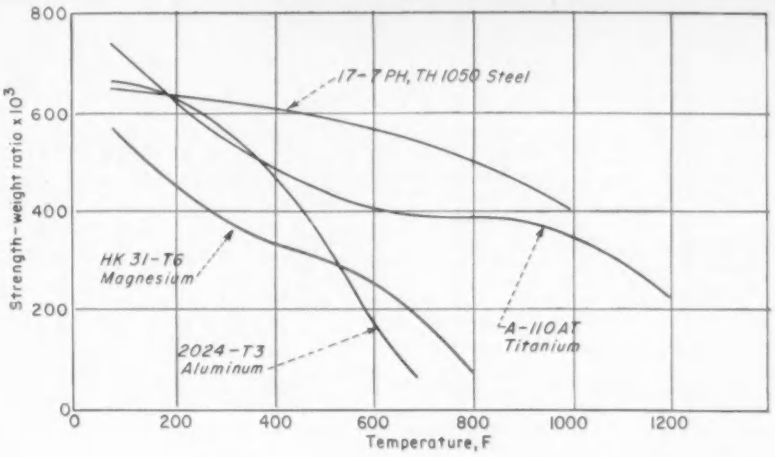


Fig. 1—Effect of temperature on strength-weight ratios of four structural alloys. Magnesium HK31-T6 superior to 2024-T6 in temperature range 500-800 F.

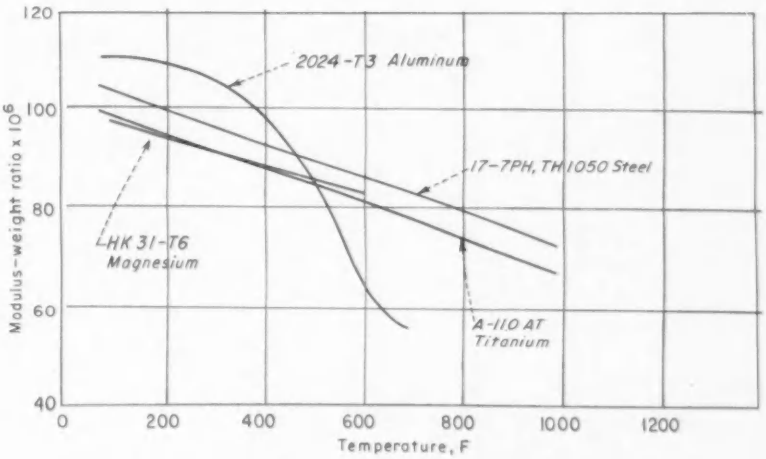


Fig. 2—Effect of temperature on modulus-weight ratios of four structural alloys. For applications requiring stiffness, HK31-T6 compares favorably with A-110AT titanium and 17-7PH stainless steel in temperature range 70-600 F.

Mechanical Properties

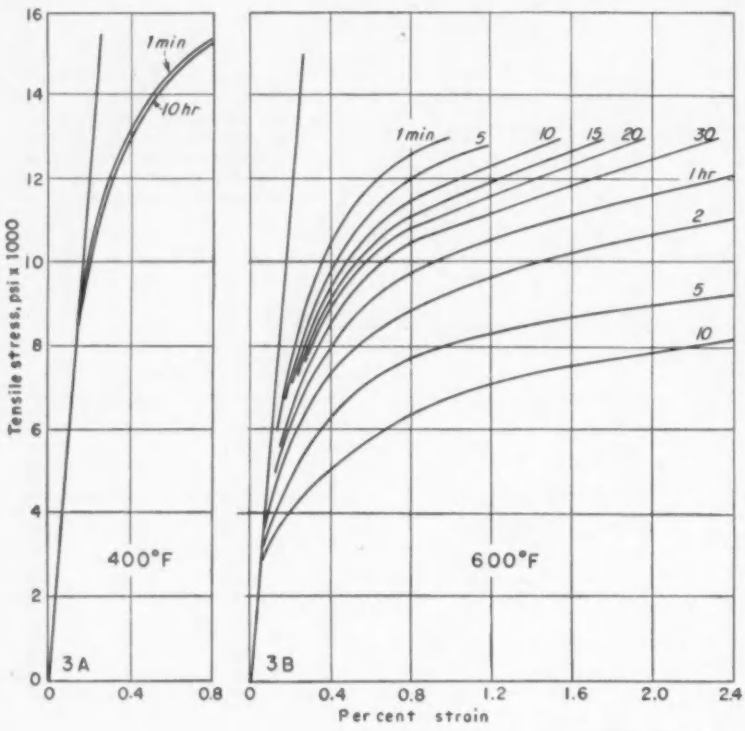
Presented here are the results of a test program on sheet HK31 in the H24 cold worked and the T6 heat treated and aged condition:

Short-time tensile properties are summarized in Table I over the 70-600 F temperature range for both base metal and fusion welded joints. Aluminum alloy 2024-T3 is included for comparison. Note that the 600 F tensile strength exceeds that of 2024-T3. Although both alloys lose strength rapidly above this temperature, HK31 may be used over 600 F if the stress level is low. The as-welded strengths show the material can be used in welded structures with confidence. Effect of elevated temperature exposure on tensile properties is shown in Table II.

Strength-weight and modulus-weight ratios, in Figs. 1 and 2 respectively, show the advantage of HK31-T6 over 2024-T3 above 550 F. Throughout its usable temperature range HK31-

Table II—Effect of Elevated Temperature on Tensile Properties of HK31 Alloy Sheet

Temper and Test Temperature	Exposure		Tensile Strength, psi × 1000	Elongation, per cent
	deg F	Hours		
T6 at 70 F	300	0	37	14
		5000	37	14
	400	5000	37	14
	500	500	35	14
		5000	31	10
	600	500	31	12
		5000	29	5
T6 at 500 F	500	0	20	21
		500	14	34
		5000	9	64
T6 at 600 F	600	0	18	22
		500	9	52
		5000	8	51
H24 at 70 F	300	0	37	8
		5000	37	8
	400	5000	37	8
	500	500	37	11
		5000	36	16
	600	500	35	21
		5000	34	20
H24 at 300 F	300	0	26	20
		5000	26	20
H24 at 400 F	400	0	24	21
		5000	24	20

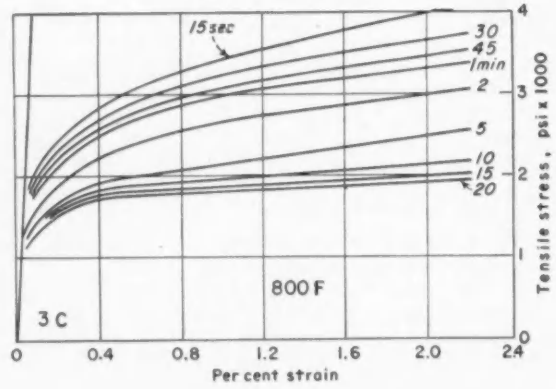


T6 has a modulus-weight ratio equivalent to A-110AT titanium and approximating that of 17-7PH, TH1050 steel. In addition, low density permits thicker sections for the same weight, thereby increasing stiffness in a given structure without weight penalty.

Elevated temperature tensile fatigue characteristics of HK31 are shown in Table III for the H24 and T6 conditions, both welded and unwelded. The indicated stresses are reasonable values for a service life of at least 300,000 cycles at 400 F and above.

Short-time creep characteristics of HK31-T6 at elevated temperatures, Fig. 3, are valuable in such short service life applications as missile airframes, power plants and pump components. Alloy deformation behavior at elevated temperature under loads of longer duration is shown in Table IV.

Fig. 3—Short-time creep characteristics of HK31-T6 sheet at 400 F, 600 F and 800 F. Specimens exposed to test temperature one hr prior to testing. Note change in vertical scale for 800 F.



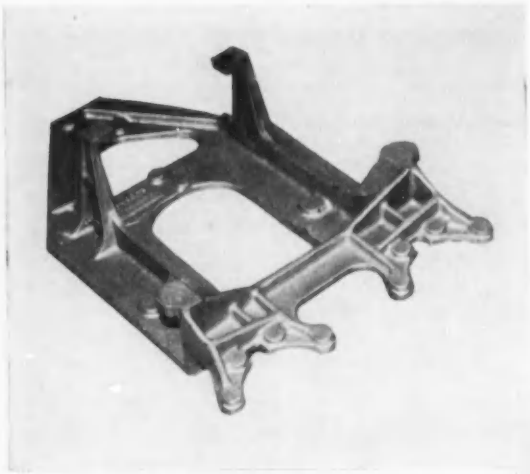


Fig. 4—Fuel control and pump mounting bracket for missile engine cast of HK31 magnesium alloy. As-received casting, though large, was dimensionally accurate.

Fig. 5—Typical missile frame and panel assembly showing riveted construction. Stiffening rings are of HK31 magnesium and 2024 aluminum alloy. Skin is HK31.

Heat Treatment

Heat treatment of HK31 magnesium in sheet form requires a special furnace, sulfur dioxide atmosphere, and special racking, straightening and pickling operations. The material should be in the T6 temper for most effective use above 500 F. For this reason, and since the alloy loses no strength after forming at 600-700 F for 5-10 min, HK31 should be procured in T6 temper to reduce fabrication costs.

Fabrication

FORMING. Magnesium HK31 follows accepted practice for AZ91 alloy; the material can be formed equally well in the H24 or T6 condition. One difference is the hot forming temperature: Alloy HK31 must be heated to 600-700 F, whereas AZ91 is hot formed at 400-500 F. The minimum bend radius, Table V, is improved by forming at elevated temperatures. The characteristics of the material indicate that it can be formed into complex shapes by any process which permits heating to 600-700 F and retention of temperature throughout the process. Spinning appears feasible provided the material is torch heated to 600 F during the spinning operation.

CASTING. HK31 magnesium in cast form is similar to AZ91 alloy in its machining qualities, but foundries consider it to be more difficult than AZ91 to cast. Fig. 4 shows a missile engine pump mounting bracket cast from HK31 alloy. Sheet HK31 may be sheared or sawed by conventional methods for other magnesium alloys. The as-sheared surface is cut approximately 20 per cent and broken 80 per cent, leaving a rough surface.

Table V—Bend Radius for HK31 Alloy

Temper	Temperature, deg F	Bend Radius
H24	70	8t
	600	4t
	650	3t
	700	2t
T6	70	6t
0	70	5t
	600	3t
	650	2t
	700	1t

t = sheet thickness

Table III—Axial Fatigue Data for HK31-H24 Alloy

Specimen Condition	Test Temperature, deg F	Mean Stress, psi	Max. Stress, psi	Total Cycles, average	Failure
Unwelded	70	15,500	17,850	330,000	None
	400	10,000	11,500	350,000	None
	600	4,000	4,600	305,000	None
As-welded, bead on	70	15,500	17,850	210,000	Edge weld area
	500	10,000	11,500	300,000	None
Welded, heat treated to T6 temper, bead on	70	15,500	17,850	150,000	Edge weld area
	500	10,000	11,500	310,000	None
	600	4,000	4,600	315,000	None

Table IV—Limiting Creep Stresses of HK31 Alloy Sheet and Plate

100 Hour Test

	Temper	Gauge (inches)	Temperature (deg F)	0.1 per cent Creep Deformation	0.2 per cent Total Deformation	0.5 per cent Total Deformation
Sheet	H24	0.064	300	20.0	12.0	20.0
		0.125	300	19.0	13.0	20.0
		0.064	400	6.0	6.0	9.6
		0.125	400	7.5	7.4	9.7
	T6	0.125	400	14.0	10.0	14.0
		0.064	500	6.2	6.1	8.4
		0.125	500	6.8	6.4	8.1
		0.064	600	1.7	2.0	2.4
		0.125	600	1.2	1.8	2.0
Plate	H24	1.125	300	19.0	14.0	19.0
		1.125	400	9.4	8.2	12.0
	T6	1.125	300	15.0	12.0	14.0
		1.125	400	17.0	9.5	14.0
		1.125	500	8.4	7.2	10.0
		1.125	600	2.6	2.8	3.7

WELDING. Fusion welding of HK-31 requires a few special techniques to produce high quality welds. The as-received material requires further pre-weld cleaning to remove a tenacious oxide film. Oxide may be removed by solvent cleaning followed by a dip in a solution of 20 per cent chromic acid and 3 per cent potassium nitrate at room temperature for 10 sec, and rinsing with hot water. An alternate to the acid-nitrate treatment is power wire brushing.

For metal thicknesses up to $\frac{1}{8}$ in. a single-Vee 60 deg included angle butt joint is used, with a steel backup bar grooved 0.125 in. wide x 0.060 in. deep along the entire joint length. Filler metal may be prepared by shearing $\frac{1}{8}$ in. strips of base metal to convenient length and smoothing the edges to eliminate expulsion of metal particles during welding. Filler metal should be cleaned prior to welding. For manual inert gas welding, about 9 in. per min. may be welded using an argon flow of 12-15 cfh through a No. 8 cup with the power supply at medium (50-120 amps) scale. These conditions assure sound welds without undercutting or lack of fusion.

Preheat and electrode angle are the most critical requirements. A preheat temperature of 450 F is necessary, and the backup bar should be maintained at 400 F in the weld area. Torch heating 2 ft lengths to 450-525 F will permit 18 in. of welding without reheating. An electrode angle of 90 deg with the work and a filler metal angle of 30 deg produces consistent

nonporous welds without undercutting.

Chipping and backwelding without filler metal at about 12 in. per min. is required to remove folds of oxide film at the root which may act as stress-raisers in service. A chipping tool rather than a grinding wheel will minimize covering of oxide inclusions by smearing.

Mechanical Joints

Assemblies of HK31 magnesium may be fastened together by conventional procedures: rivets, bolts and inserts. Monel and 2024 aluminum rivets have been successfully used as well as stainless and nickel plated alloy steel bolts. The major problem is atmospheric corrosion and galvanic action between alloy and dissimilar metal adoining pieces and fasteners. While the corrosion protection for magnesium alloys cannot be fully discussed here, HK31 is more corrosion resistant than other magnesium alloys. A successful and simple treatment for assembled structures, such as the missile panel and frame construction in Fig. 5, is spraying the entire surface, including fasteners, with epoxy resin. Excellent corrosion resistance is obtained if this coating is applied in addition to an anodic coating such as Dow 17.

New Developments

The Dow Chemical Company has developed a second magnesium-thorium alloy designated HM21XA-T8 (XA for experimental alloy) now available for evaluation. This alloy extends the usable temperature range of HK31 for prolonged exposure to 700 F. Tests indicate HM21XA-T8 may be useful to 900 F.

EDITOR'S NOTE—Other recent articles on light alloys include the following:

"Aluminum Extrusions", October 1956 page 200; extrusions classified by shape, alloys available, evaluating proposed shapes, tolerances and costs.

"Forming Titanium Sheet", February 1956 page 135; design recommendations for simple bending, drawn flanges, rubber forming, stretch forming and drop-hammer forming; springback allowances and prevention of buckling.

"Effect of Elevated Temperatures on Mechanical Properties of Magnesium", 1956 Annual Digest, page B14; graphical and tabular data showing influence of short-time heating, prolonged heating and cyclic elevated temperature exposure for cast and wrought magnesium alloys.

Report on Four Precipitation-Hardening Stainless Steels

BECAUSE THE PRECIPITATION-HARDENING STAINLESS STEELS are considered competitive with titanium for some aircraft applications, the Titanium Metallurgical Laboratory at Battelle Memorial Institute, Columbus, Ohio, has devoted Report No. 48 by D. B. Roach and A. M. Hall to these significant new materials.

The precipitation-hardening stainless steels offer attractive combinations of properties up to temperatures of 700 F. They have good strength-to-weight ratios, high moduli of elasticity, good stress-rupture and creep properties, and good fatigue properties. In addition, the alloys show similar properties in both the longitudinal and transverse directions and in tension and compression. Two of the alloys (17-7PH and AM 350) have excellent formability as annealed. All four of the presently developed alloys are relatively simple to fabricate and can be welded and brazed, but, generally, heat treatment is required after welding.

The alloys are not difficult to melt and cast, and could be produced in practically any integrated steel mill having electric-furnace capacity. However, careful control of chemistry is required to maintain consistent strength properties. The only critical alloying element required in the preparation of the alloys is nickel. Scrap presents no difficulty, since it can be used as remelt stock for either precipitation-hardening or common stainless.

To obtain the typical or guaranteed properties, the heat-treating instructions recommended by the producers must be closely followed. Inconsistent heat-treatment control will result in erratic properties. Likewise, care in handling these alloys during fabrication and heat treatment is a necessity. Any nitriding or carburization of these alloys may result in inferior properties. Excessive scaling may also be troublesome. However, when the necessary precautions are taken, consistent properties can be readily obtained.

Precipitation-hardening stainless steels are available in a wide variety of sizes and shapes. However, all four alloys are not available in all shapes and sizes. Alloys 17-4PH and 17-7PH are warehoused, AM 350 will be warehoused, and Stainless W is made on special order only.

Stainless W is 16-18 per cent chromium, 6-8 per cent nickel, 1 per cent each titanium and aluminum, having 0.12 per cent carbon, max. Alloy 17-7PH also has 16-18 per cent chromium and nickel 6.5-7.75 per cent, aluminum 0.75-1.50 per cent, maximum carbon 0.9 per cent. The other austenitic material, 17-4PH has 15.5-17.5 per cent chromium, 3-5 per cent nickel, 3-5 per cent copper, 0.07 per cent carbon, max. AM 350 is a 16.25-17.25 chromium alloy, 4-4.5 nickel, 2.5-3 molybdenum, 0.10 carbon, max.

Tensile Stress-to-Rupture Properties

	In 100 hr		In 1000 hr	
Test Temp., F	Stress, 1000 psi	Elong. in 2 in., per cent	Stress, 1000 psi	Elong. in 2 in., per cent
Stainless W (Aged 1000 F for 1 hr)				
1000	31.5	...	...	...
1200	12	...	...	...
17-7PH—Condition TH 950				
600	162	9	161	7
700	141	4	138	3
800	124	6	100	5
900	73	15	57	21
17-7PH—Condition TH 1050				
600	170	19	158	17
700	130	21	122	24
800	110	21	90	23
900	78	30	52	40
17-4PH—Condition TH 900				
600	154	2.5	148	2
700	134	2	130	2
800	130	4	89	4
900	81	4	48	17
AM 350 (refrigerated and tempered)				
800	164	5	161	6.5
900	107	6	99	8.5
1000	63	15	53	...

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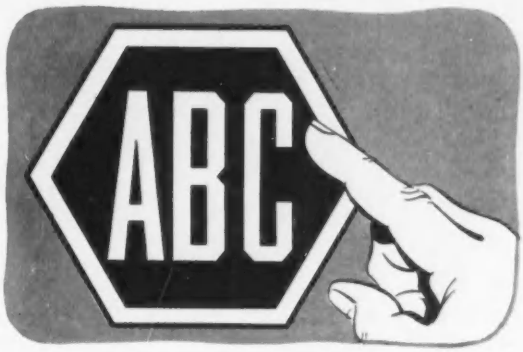

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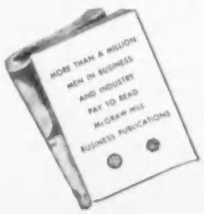


McGRAW-HILL MAGAZINES

McGRAW-HILL PUBLISHING COMPANY, INC.

330 WEST 42nd STREET, NEW YORK 36, N. Y.

TECHNICAL NEWS

1957 CARS

Still Longer;

Getting Lower

Lincoln Features Quadra-Lights

The '57 Lincoln has not greatly deviated from last year's winner of the Industrial Designers Institute award. It is slightly longer (224.6 in. overall length with a 126 in. wheelbase) and features four road lights in vertical pairs. Massive parking lights and directional signals are coupled horizontally below the headlights. Horsepower and torque have been increased as the result of a higher compression ratio of 10 to 1, reshaped pistons, and a redesigned combustion chamber. Horsepower has been raised to 300 at 4800 rpm with a torque rating of 415 ft-lb at 3000 rpm. The new four-barrel carburetor will have larger float bowls while a new distributor that incorporates both vacuum and centrifugal spark advance systems will insure correct ignition timing at all engine speeds. A paper air cleaner and an oil filter that is a sealed throw-away unit are also new additions. Lincoln has added power brakes, the four-barrel carburetor, and dual exhausts, as standard equipment to all seven models of its new line. This augments the other standard equipment of power steering and Turbo-Drive transmission in the Premiere and Capri series. A power-directed differential that will provide better traction is offered as optional equipment.

Mercury: Comfort and Horsepower

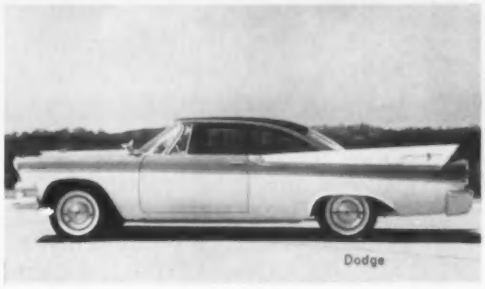
The '57 Mercury series will consist of the Montclair (pictured below) and the Monterey. Both cars are 4.6 in. longer and 2.3 in. lower than last year's models as a result of an alteration which moved the chassis side rails outwards and lowered the floor pan between the side rails. The roof, in order to maintain easy access, is a thin, structurally reinforced design. Over-all glass area has been increased by 20 percent.

Design changes in body suspension include a balance between front and rear. A difference of 10 cycles per min is used, with the front suspension being the lower frequency. Road shock cycle frequency is 60 cycles at the front and 70 at the rear. The rear suspension features a large ring eye at the front end of the rear spring. The eye has a six inch diameter and is encased between two air-filled rubber doughnuts, which in turn are held in place by a metal shielding cover. Mercury engineers claim that 80 per cent of all vibration in the rear suspension are transmitted to the car through the front end of the rear springs.

The frame is 12.5 in. longer and 14.5 in. wider than last year's frame and is of ladder-type construction with box section side rails and five cross numbers of boxed hat, tubular and channel types.

A ten per cent increase in horsepower has been achieved on the 312 cu in. engine by increasing the size of the intake manifold passages, increasing the size of the intake valves and ports and increasing compression. The engine features a four Venturi, downshaft carburetor with paper air filter.

Chrysler's Family Tree



Chrysler Corp.'s total investment in the 1957 line shown here, was over $300-million with perhaps the greatest concentration being on reduction in height, and longer sweeping tail fins (left). Hardtop and convertible models have been lowered as much as 5 in., and the two- and four-door sedans 4 in.

The Plymouth (left and right) and Dodge have been widened almost 4 in. The station wagon for the Plymouth has a wheelbase 7 in. longer. Originally planning only one V-8 for all of their cars, Plymouth, at the last minute, decided to put a more powerful V-8 engine in its two better cars, the Savoy and Belvedere. It will have a compression ratio of 8.5 to 1, and a cu in. displacement of 302. The Plaza will have a V-8 with a 277 cu in. displacement and a compression ratio of 8.5 to 1, up from 8 to 1. A 6-cylinder engine also will be available. Chrysler's 3-speed transmission will be available as an option on only the Belvedere.

The Dodge Red Ram V-8 engine has an increased bore and stroke increasing the displacement to 325 cu in. Two-barrel carburetion is standard on the Dodge-6 and Red Ram V-8, while Custom Royal V-8 will carry a 4-barrel carburetor. Push button Power Flite transmissions are optional on the six and V-8 models, with Torque-Flite available on the others. With this type of push button, three-speed automatic transmission, the neutral button will act as the starter control, replacing key starting. With this system the neutral button is pressed, automatically shifting the Torque-Flite out of gear. An additional push compresses the spring that actuates the starter switch. The 1957 Dodge truck also will have a push-button control for a 3-speed automatic transmission.

To the lineup of **De Soto's** Fireflite and Firedome V-8's has been added the Firesweep for 1957. The first two engines upped the compression ratio from 8.5 to 1 to 9.25 to 1. Both bore and stroke have been increased to 3.78 in. x 3.80 in., making the displacement 341 cu in. The

new Firesweep will use the old Dodge Red Ram engine with a compression ratio of 8.5 to 1 and a displacement of 325 cu in. The Firesweep will be the shorter of the De Sotos with a wheelbase of 122 in. The 9-passenger Plymouth Suburbans and the Dodge and De Soto station wagons will have rear-facing third seats. Folding away flush with the car floor, it offers quick cargo space. Entry to the third seat is via the rear bumper and tailgate.

More power is the byword for **Chrysler** Firepower V-8 which will go in the New Yorker. Displacement has been increased to 392 cu in. by enlarging the bore to 4 in. and lengthening the stroke to 3.9 in., the latter being possible by increasing the cylinder block height. The compression ratio was upped to 4.25 to 1. The Windsor and Saratoga Spitfire V-8 has had its displacement increased to 354 cu. in., with the compression ratio also upped to 9.25 to 1. The Saratoga is last year's Windsor with a new name. The Windsor still remains Chrysler's cheapest car. Standard equipment on the New Yorker is 4-barrel carburetion. All of the company's cars will offer dual headlights in each fender pod in states where legislation permits their use.

The 1957 **Imperial** line will have three models—the Imperial, Imperial Crown, and the Imperial Le Baron. For the first time there will be a convertible, a model previously built only to special order. The Imperial will use the same Firepower engine used in the New Yorker. Wheelbase of the Imperial will be 129 in.; length over-all 224 in.; width 81.2 in.; and height 56.7 in. All five of Chrysler Corp.'s lines will use the new 14 in. wheel, although this is not a major factor in lowering the new cars. A new suspension system for all of the cars will reduce "diving" of the front end by 60 per cent when the car is braked to a quick stop. Called Torsion-Aire, it also permits flat, fast cornering, and cuts down on vibration and noise by using rubber at all key points to isolate the rider from the road. Major elements are the front suspensions which have torsion bar springing. Found this year on the push button shift panel are push button operated turn indicator lights.

English Gas Turbine Car with Plastic Body

An English sports car with a laminated plastic body has been designed around a lightweight, high torque, 110 hp, gas turbine mounted in the rear. An unusual transmission feature is a 4-wheel drive. The company, Rover Ltd., Birmingham, England, says this is necessary because the engine's high starting torque characteristic, combined with the low weight of both the engine and chassis would cause wheel spin if not divided over all of the wheels.

As with all turbo-cars, there is a straight 2-pedal control, without clutch or gear box. The transmission follows racing car practice with independent front wishbones and coils, and a De Dion rear axle. The Motor Industry Research Association puts the fuel consumption 13-14 mpg at a speed between 40 and 80 mph. The speed is about 110 mph. These high rates are said to be caused by: a gas temperature of 1560 F; a compression ratio of 3.85 to 1 from a single small centrifugal blower; a high engine speed of 52,000 rpm (minimum kick-over is 15,000 rpm); and a simple, but compact contra-flow plate heat exchanger. Exhaust temperature is reduced to 390 F, and can be safely exhausted through a luggage boot top.

The turbine was developed from the larger unit first fitted in a standard Rover car which attained a world's speed record of 152 mph. in 1952.

With a single stage centrifugal compressor directly driven by a single stage turbine at 52,000 rpm, exhaust gases drive a second turbine independently mounted turbine. This transmits torque to the wheels through a reduction gear of 7.45 to 1. This unit also includes a reverse gear.

For starting, the compressor is accelerated to 15,000 rpm by a 12-v motor through a 10 to 1 step up gear. This cuts out automatically when self sustaining compression is reached. Control's solely through the accelerator pedal which controls hydraulically the centrifugal governor on the fuel injection unit.

The car's wheelbase is 94 in.; length over-all 149.75 in.; height 53 in.; over-all width 59.25 in.; and ground clearance is 6.125 in.

Although both engine and transmission have been well developed, the company says that they have no firm production plans as yet.

Russian Machine Rolls Liquid Steel

A machine which rolls liquid steel of 1.6 per cent silicon and 0.7 per cent manganese into a sheet of from 0.6 millimeter to 0.8 millimeter thick, is currently being used by the Russians. Following this operation, the steel sheet is then tempered and used in the construction of agricultural machinery and for roofing.

American Motors' Look-Alikes

Nash The Nash for 1957 follows the trend of the lower, European concept in car design. Lower than the '56 model by two inches with an over-all length of 209¼ in.; the new Ambassador (pictured above) has also adopted the four-headlight system. All four lamps are used for the high beam, while only the upper two are used for low beam. The roof has been lowered 1¼ in. and the new models have a 14 in. wheel base, instead of their customary 15 in. wheels. Horsepower in the V-8 engine has joined the American horsepower race climbing to 255 hp this year against 220 hp in '56. The engine has a displacement of 327 cu in. with a 9 to 1 compression ratio . To improve riding comfort, frictionless coil springs on all four wheels, wider tires (800 x 14) and an 18 to 1 ratio gear box for steering improvement are featured. Reclining seas, twin travel beds, deep-coil suspension and unitized construction, in which body and frame members are fused into one integral unit are features of last year's models that will be incorporated into the 1957 models as well.

Hudson The Hudson Hornet (picture above) for 1957 has a 121¼ in. wheelbase and is two in. lower than the '56 models giving it an overall height of 60⅜ in. The new models are equipped with 14 in. wheels, and a roof panel that has been lowered 1¼ in. at the center line. The car has a 255 hp engine with compression ratio of 9 to 1 and a 327 cu in. displacement. Its base and stroke are 4 in. by 3¼ in. The V-8 engine is equipped with a four-barrel carburetor and dual exhausts as standard equipment. Both tailpipes point downward and are hidden by the bumper to prevent blackening of the bumper's chrome by exhaust fumes. The kingpin type front suspension has been replaced by a steering knuckle assembly which pivots on anti-friction bearings, thus making steering easier and smoother. Hudson's single unit body and frame construction is formed in one rigid, integrated unit. Power brakes are standard equipment on all custom models. Padded instrument panels and the reclining seat-twin bed combination are standard on all Hornet models.

Its V-8 engine is available with three transmissions: standard synchromesh, optional automatic overdrive, and Hydro-Matic. An air conditioning system is offered as optional equipment. The system combines heating, ventilating, and refrigerating in one unit, operated by a single knob control. The entire system is located forward of the dash panel without components in the trunk. A transistor-powered radio will also be offered as optional equipment. The new radio will eliminate power transformers.

Rambler The Rambler became a separate make automobile when it made its debut this year. In the past the car was known as the Nash Rambler or Hudson Rambler, depending on which dealer sold it. Instead of featuring length, the Rambler relies on compactness as a selling point. It is about a foot and a half shorter (191 in. over-all) and several inches narrower (71½ in. over-all) than the average U.S. car. The 6-cylinder engine has been boosted to 125 hp while the V-8 can develop 190 hp, one of the highest power-to-weight ratios in the industry. The V-8 engine has a 250 cu in. displacement with an 8 to 1 compression ratio. A twin-barrel carburetor is standard on the V-8 and optional on the "six." Reclining seats and twin travel beds continue to be offered on all Ramblers. The station wagon (pictured above) continues to have a roll down rear window, which eliminates the inconvenience of lifting the upper section of the loading gate. Steering is improved on the new Rambler as a result of a steering box. The turning diameter is 37½ ft. Power steering is also offered as optional equipment. The use of long coil springs on all four wheels has been retained to reduce sway when driving around curves.

Walk Away From a 50 Mph Head-on Collision

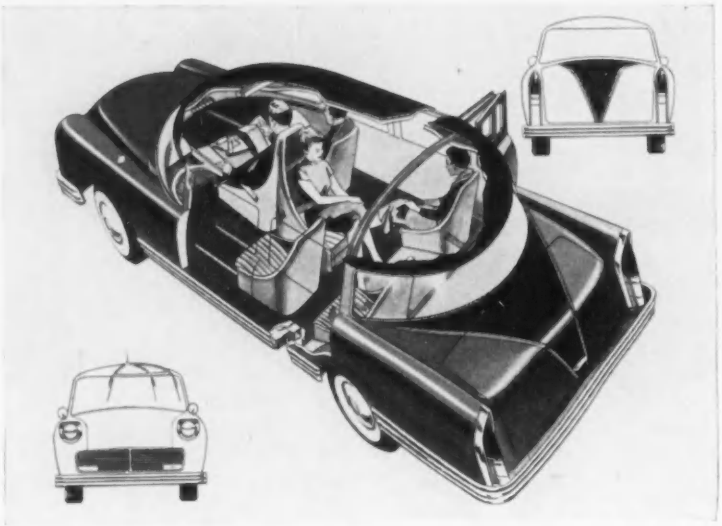
No competitor of the Detroit automobile builders fraternity, the Cornell Aeronautical Lab., Inc., Buffalo, N. Y., announced its 1957 model in the form of a "crash-proof" car. Not concerned with the spiraling horsepower race, increased car length, reduced height, higher rear fenders, or style in general, Cornell is interested only in saving the lives of the car's occupants. The new crash-proof car is not expected to be a prototype for mass production; rather a safety vehicle which will protect the driver and passengers from a head-on collision at 50 mph.

Cornell feels that if proper attention is paid to lessen the effects of an auto crash, the injury and death rate might be decreased by as much as 50 per cent. Echoing this viewpoint is an interested party and co-sponsor of the crash-proof car project, Liberty Mutual Insurance Co.

Seats • Perhaps the most noticeable difference in the car as compared to conventional cars is the seating arrangement. The driver's seat is in the center of the car, giving him maximum visibility and protection. Tests have shown that if the driver can be protected so that he can maintain control of the car, many minor collisions can be prevented from becoming major ones.

All of the seats are "bucket" type. The two front seats adjacent to the driver are mounted on tracks and can be moved to the rear when entering or leaving the car. The driver's seat, and the rear facing seat built onto it can be moved 11 in.; the two passengers' seats 20 in. Another reason for bucket seats is that they give a considerable degree of body restraint. Also, they are regarded as more comfortable than the conventional seats, and reduce riding fatigue.

The three rear seats are fitted with seat belts, while the driver's and two front passenger seats have a web-type yoke held in position between the two side arms and a semi-rigid contoured cross member. This combination restraining member and chest impact pad is stowed forward and is pulled into position when the passenger's seat is in position.



NEW SEATING ARRANGEMENT and unusual steering mechanism are shown in Cornell Aeronautical Lab.'s new safety car. Note safety yoke and protective chest pads in front of driver and front passenger. Identical unit for left front passenger is shown in its stored position when not in use. Distant dashboard also prevents injury. Between side bumper and frame is heavy impact absorbing material. Cornell also is stressing a definite front and rear design. Many people claim that at high speed it is difficult to tell whether some modern cars are coming or going.

Steering Control • All injury-producing objects, the steering wheel, post and horn ring, have been eliminated and have been replaced by a simple full hydraulic, two-handled lever-type control system set parallel to the floor. The hydraulic system is called: a variable ratio, variable force, variable control rate system. The control motion relative to the position of the front wheels may be varied by the selective design of the cam slot through which the control yoke rotational movement is converted to linear motion.

The control forces, which are induced by spring loading the control yoke, can be set at any value by the selective design of the spring.

The control yoke movement rate is controlled by the addition of a pneumatic dash-pot arrangement. This is considered necessary since the actual control movement provided is greatly reduced from that to which drivers are accustomed. The dash-pot would insure against over control which might otherwise result from the increased control sensitivity. It has been considered that eventually it may be possible to provide a variable rate control which uses the vehicle's velocity as a function.

Other design features: Two-section doors hinged at the center and to the rear body post. The front edge is fitted with rollers. The door is kept closed by bolts into the top, bottom and sides of the door.

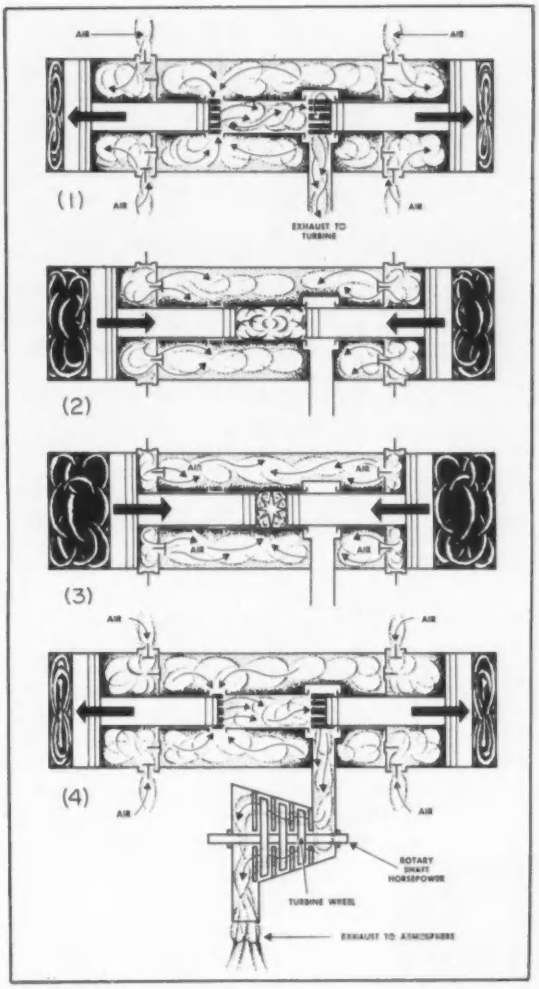
Wrap around front, rear, and side bumpers.

Roof padding throughout.

Two W-shaped sheet metal stiffeners in the roof as a safeguard against crushing, and several "roll-bars."

While not expecting the car to be copied by Detroit designers, Cornell hopes that gradually some of the ideas will be adopted.

Already the seat-belt, stronger door latches, and foam dashboards and visors have been accepted. However, any automobile designer will tell you that people are not too interested in safety. Sales records show this.



Operation of a free-piston engine

1—Pistons are completing their travel outward and are about to bounce back. Intake and exhaust ports are open, and intake air is filling compressor cylinder.

2—Pistons travel inward pumping air from the compressor cylinder into the air box, trapping air in the combustion space. Intake and exhaust ports are closed; air delivery valves are open.

3—Pistons are completing their inward travel. Fuel is injected into cylinder. This is combustion and the beginning of the power stroke. Intake and exhaust ports are still closed—air delivery valves are open.

4—End of power stroke, compressing air in bounce space, which return pistons for next cycle. Exhaust and intake ports are just opening to scavenge the cylinder. Exhaust gases escape to turbine, to develop usable power. Air is being drawn into compressor cylinder. Already developed is General Motors' prototype XP-500 which is powered by a free piston engine, and will burn animal, vegetable, or mineral oils. A larger version of this engine will be installed in a Liberty ship in a government experiment aimed at speeding up and finding some use for this World War II ship. See page 214.

Automotive Gas Turbine Gets Competition

Research departments in the automobile industry are going all-out in two different fields to battle the threatened oncoming of a gas turbine engine for automobiles.

Those in favor of the free-piston engine fully believe they lead the race, principally because they have made giant strides in their type of propulsion in the past six months. The driving turbine has been moved from the rear axle up to the engine compartment, thus eliminating two of the biggest drawbacks to the engine: the difficulty of operating water pumps, oil pumps, generators, etc.; and the rather hot exhaust necessary to drive the turbine.

The accessory equipment now can be operated by a stub shaft out of the reduction gear box in the engine compartment. (Prior to moving the turbine to the engine compartment, the only alternative was to drive a powerful generator at the rear axle and operate the auxiliaries electrically).

Noise, another big "if" in free-piston development is well on the way to being whipped. But as yet unsolved is the problem of supplying vast quantities of clinically clean air to the engine. It has been reported that on the basis of present day filters the size of a filter for a free-piston engine would be prohibitive.

One company says that the answer probably is the development of a precipitron device—one that would charge incoming dirt electrically and then trap it on a filter of the opposite polarity. This precipitron would have to be no larger than twice the air filter used in present day cars, and would have to cost about $15. Preciptrons now used for room air cleaners sit in the window, are large, and cost about $150. The auto precipitron would have to screen out everything larger than five microns.

Meanwhile:

Adherents of another engine, the familiar gasoline driven reciprocating engine—are planning a large redesign program for that engine. The engine will be flatter, much lighter, and will reach and even pass the one-horsepower-per-pound-of-weight work mark that long has been sought. With new design features, more extensive use of aluminum and aluminum irons, it will be possible to get as much as 1.25 or more horsepower per pound of engine weight.

It is quite possible that there will be opposed type piston engines, with the pistons varying from 5 to 7 in. in dia with a one-in. stroke. Crankshafts, in such an engine, would of necessity be a straight shaft with eccentrics replacing the crank sections.

Such types of engines have been tested, and it is reported that they would be much more efficient. Compression ratios would be around 15 to 17 to one; the engine would be easier to work on and require less maintenance than those used today; and would not require extensive retooling for production.

Such an innovation, according to reports, will be around in about four years.

Electronic Fuel Injection Unit For '57 Cars

The Bendix fuel injection system is a departure from the usual concept of fuel injection in that the injection of fuel into the cylinders is not dependent upon mechanical operation of the engine. It is an "electronic system"; no special drive is required from the engine. It does not measure fuel, but time, is accurate to one-thousandth of a second, and supplies fuel in varying amounts, or time, to meet all engine requirements. Fuel is always present at the injector at 20 psi. The injector is opened electrically and held open for a duration of time suited to meet the needs of the engine.

There are few parts, and all but two have had long testing and observation as aviation components. An electric pump, located at or near the fuel tank keeps a constant supply of fuel circulating through a common rail system. The rate of flow is about 6 gal per hour, and is maintained no matter what the engine does. Piping from each injector is tied into the common rail.

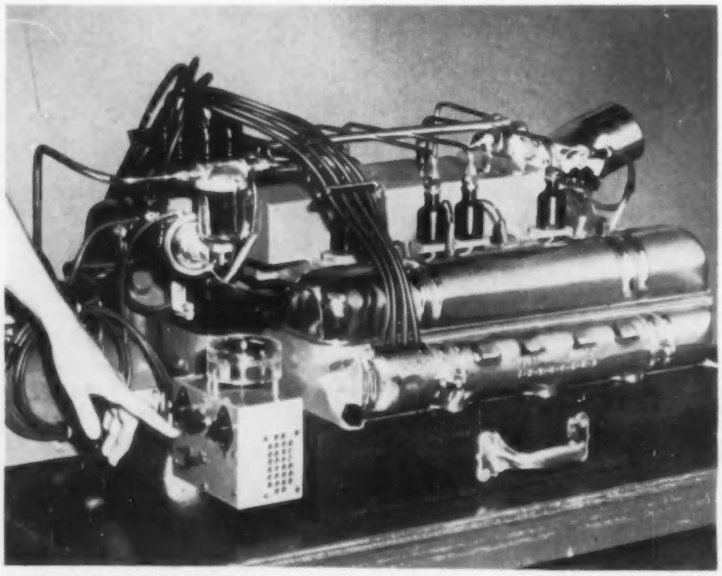
A "sandwich" (consisting of a commutator, a rotating brush driven by the distributor cam, and a condenser) is inserted between the distributor and the distributor cap. This sends a signal to an electronic modulator which amplifies it and sends the impulse to the solenoid activated injector to inject the fuel into the cylinder.

Sensory equipment mounted in the engine itself plays an important part in the operation of the fuel injector. The sensing device analyzes the immediate needs of the engine and sends signals to the electronic modulator. The modulator then varies the length of time of the pulse signal that operates the injectors which in turn control the amount of fuel to be injected. The pulse signal width, or length of time of the electrical signal, can vary any place from 0.5 to 3.0 milliseconds.

These sensory signal devices are mounted: (1) In the intake manifold to measure intake manifold pressure; (2) On the throttle shaft to interpret enrichment needs; (3) On the throttle shaft to interpret idle range demand; (4) In the water jacket or exhaust manifold to interpret choke requirements; (5) In the throttle body as a deceleration control unit; (6) In the engine compartment, an altimeter to assure proper mixture no matter what the barometric pressure or altitude.

Bendix points out that in normally "crisp" weather the automatic choke on a car will stay in the closed to partially closed position, sending a rich mixture to the cylinders for about 30 miles. With the fuel injector unit, the mixture is leaned out to maximum operating efficiency within ¾ of a mile.

Other advantages claimed by Bendix: about a 5 to 10 per cent better economy than in carburetor equipped car; About a 10 per cent increase in useable torque—peak torque is reached at 25 mph, while in a carburetor equipped car it is about 50 mph; Less maintenance; No vapor lock; No throttle valve icing; Faster response to throttle; Better cylinder distribution of fuel; Faster cold starting. No need to purge system of air if fuel tank runs dry; and no "cold exhaust" on a dual-exhaust system.



WITHOUT A CARBURETOR AND AIR CLEANER, top of engine equipped with electronic fuel injection unit has new profile. The essential parts of the new system, called Electrojector, are the small, dark, vial-shaped injector units near the top of the cylinder head, and the small transistorized control box at the lower left. With printed circuits, Bendix hopes to get the size of the box down to that of the present day voltage regulator. The unit requires no direct drive off the engine.

Closed Cycle Jet for Inter-Space Flight

A cosmic ship that could approach the speed of light may be propelled by a jet unit which would not lose any of the gases that were required for producing the motion. Developed in Italy by Adelmo Landini, the unit consists of a small atomic pile which superheats a compressed gas. The gas is then sent under high velocity into a long decompressing chamber ending in a closed tubular spiral and kept at low temperatures by a refrigeration system. The extreme sidereal cold existing in cosmic space would also be a prime factor in refrigerating the gas. Before reaching the end of the decompressing chamber, the gas would condense and return to the boiler where it would again evaporate and be compressed.

Studebaker—About The Same

Studebaker for '57 has made no radical mechanical design changes. They will still present their Champion six-cylinder series, Commander V-8 and President V-8 (pictured above). The President has a 289 cu in. engine displacement, the same as last year, but has increased its compression ratio from 7.8 to 1 to 8.3 to 1. The company claims an increase in horsepower and torque in all models except the Champion six which will remain 101 hp. One new feature on the '57 Studebaker is a variable rate control of front-coil springing. Standard on all sedans, the new spring development is to give the same degree of soft ride with one to five passengers as is obtained by conventional coil springs only with a heavy load. The principle is that individual coils compress one by one at an unequal rate, coil by coil.

This compares with the conventional springs which compress at an equal rate, leaving the same spacing between each coil under all load conditions. With Studebaker's spring, the spring coils as they collapse, are eliminated from the springing action. This actually lessens the springing surface and causes the spring to become stiffer as the load increases, giving a comfortable ride throughout the spring range.

Studebaker will continue to produce the Golden Hawk. However, a supercharger, driven through a variable rate pulley, has been added to the '57 models.

News From Abroad....

London—Magnesium Elektron recently demonstrated a new system of producing magnesium at Clifton Junction, near Manchester, England. The process has been developed because the high cost of electricity and materials has rendered the electrolytic method uneconomical. It involves the reduction at high temperature and under vacuum of briquettes made of calcined dolomite and ferro-silicon. The magnesium metal is liberated as vapor and condensed in the form of crystal metal on the cool end of retorts. A pilot plant is already in operation.

Big advantages claimed for the process are that heat is obtained with low-grade oil and extensive reserves of dolomite are to be found in the Pennine range of hills in England. The ferro-silicon is imported from Norway, but the short sea passage keeps the cost low.

The magnesium produced will be competitive in price with that produced anywhere in the world, the company claims, and when the plant is in full production, imports of magnesium will be reduced considerably.

London—A new impact material for injection molding, and a sheet material for vacuum forming has been developed by Kleestron Ltd., London, England. The impact material, known as Kleestron Super 44 is an improved grade of polystyrene which is available as colored pellets or dry coloring granules. An assortment of colors is available, and the material can be used for a wide range of components.

The sheet material for vacuum forming is extruded impact styrene sheeting which is available in 48 in. widths and lengths up to 96 in. Thickness is from 0.015 to 0.250 in.

Bonn, Germany—Coating steel, concrete, and other metal containers with plastic is reported to be possible with Neutralith-W 56, a new plastic coating developed by Fritz Krick Co., Frankfurt, Germany. The plastic consists of two components: a polyester and hardener which through chemical reaction and a catalyst hardens the liquid foil within 2 hr.

Neutralith-W 56 has a smooth surface so that it can be easily cleaned. It is resistant to acids, leaches various other chemicals, and has a high temperature stability.

The same firm has also developed a new system of indirect panel cooling for reinforced concrete storage tanks and fermenting vats in breweries. The cooling pipes are transferred inside the walls and are closely connected with the structural steel netting which is used as cooling distributor. From here the cold is transmitted to the concrete and thence indirectly to the beer by means of the tank walls. At the outside the concrete protects the cooling pipes against corrosion, while the cooling medium prevents the corrosion on the inside.

Bonn—A new group of plastics, named polycarbonates, has been developed by Farbenfabriken Bayer in the Krefeld-Uerdingen plant. The polycarbonates have unusually high melting temperature and are insensitive to continuous heating as well as humidity. In the melted condition, they are capable of withstanding temperatures of over 575 F for a long period without decomposing. The new plastics are suitable for electrotechnical purposes. The polycarbonates are transparent and almost colorless.

Liberty Ships Get New Lease On Life

Government experiments to speed up its fleet of mothballed Liberty ships to keep pace with present day national defense requirements has shot past original expectations and is creating a stir of interest in the shipping field. Four experimental ships will be in operation by the end of the year.

Biggest cause for excitement is a 6600 shaft hp gas turbine engine that boosted a 10-knot Liberty to over 18 knots. It is the world's biggest ship to be propelled by a gas turbine, and the first merchant ship to be outfitted with one. Builders of the gas turbine, General Electric Co., say it holds high hopes for ship operators; initial costs are less than conventional engines; operations are more efficient; and engine room crews can be reduced.

Right now, there are some 1500 war-built Liberty ships in the government's reserve fleet. In case of war, these ships would be called on to furnish logistic support to our fighting forces. The big drawback, however, is that the ships are too slow to meet today's defense requirements. They can only make 10 knots. The Department of Defense has set a minimum speed requirement of 15 knots for supply ships.

In 1954, the government began a $12 million dollar experimental program on four Liberty ships to see what would be necessary to hike their speed to the 15 knot level. Dual purpose of the experiments is to meet defense requirements and do spade work for modernizing the operating merchant fleet, largely due to be replaced in the next ten years.

Four different types of high powered propulsion machinery were selected to be installed in the experimental ships. All will increase the speed to 15 knots and range from existing steam turbines that the maritime Commission has stockpiled that could be installed in the fastest possible time, to new types of propulsion machinery that has never been used in U. S. merchant ships before. All units have been equipped to burn low cost bunker "C" fuel, which costs about one-half as much as Diesel fuel normally burned in some of the new machinery.

To compensate the ships for the increased speed, three of the Liberty ships were given new hull designs. This consisted of removing an 82 ft section of the existing blunt nosed bow and replacing it with a more streamlined 107 ft section; net increase in length of the ship is 25 ft.

One ship was left with the same hull design, the idea being that a national emergency might not allow time for the more complicated type of conversion, and test data is needed to see how the ship performs with the increased speed. This ship is outfitted with existing propulsion machinery, making it the fastest type of conversion possible.

The government will charter the four ships to private steamship companies for at least two years to see how they work out under actual operating conditions. Government technicians will keep performance records of the ships with results available to the shipping industry. Right now, the government does not have plans to launch into a mass conversion program of its mothballed fleet.

Along with testing out new pro-

FIG. 1—A common sight on the high seas in World War II, the EC-2 Liberty ship (top) could be recognized at a distance, head-on, because its blunt bow made it look like it was pushing the rest of the sea in front of it. Often called a "rust bucket," it needed a good following sea to make 11 knots with its 2500 hp triple-expansion steam engine. There are about 1500 of these World War II ships in the reserve fleet. The new Liberty ship, John Sergeant, (bottom) is hardly recognizable with its new streamlined bow which added 25 ft. to its already 456 ft. length. A streamlined smokestack replaces the old mushroom type. Big change is the 6,000 shp gas turbine which replaced the original power plant, and gave a test-run speed of 18 knots.

pulsion machinery, the Maritime Administration is also running experiments of new types of cargo handling gear. It is designed to meet requirements for today's military cargo and to see if port costs for existing merchant ships can be cut, see Fig. 4.

The Changes Made

Here are the changes that have been made in the four ships:

SS BENJAMIN CHEW—A minimum number of changes were made in this ship to make it acceptable for defense use. Its steam reciprocating engine (Fig. 2) was replaced with a new 6000 shaft hp steam turbine and reduction gear to increase the speed to 15 knots. No hull changes were made, but existing cargo handling gear was replaced with similar type, heavier lifting capacity booms to handle today's military cargo. Conversion work on the Chew cost $1,079,000. The Maritime Administration furnished the new steam turbine from its equipment stockpile. Sea trials were held in August with a 15-knot speed maintained.

SS THOMAS NELSON—Both hull design and propulsion unit changes were made. An 82.5 ft section of the bow was chopped off and replaced with a new 107.5 ft section to give a net increase in length of 25 ft. Finer lines were incorporated in the new bow to improve movement of the ship through the water.

Present propulsion machinery was replaced with two Baldwin-Lima-Hamilton 3000 shaft hp Diesel engines driving through a reduction gear. Fuel treatment equipment has been installed to allow for burning bunker "C" fuel, which costs about half as much as marine Diesel oil. Included in the fuel treatment plant is a dual automatic desludging heavy fuel oil purifier, and a viscosity control unit that takes continuous samples of oil.

The conventional cargo handling gear has been removed from the Nelson and replaced with five 5-ton capacity electrohydraulic, level luffing cranes (Fig. 4) set on tracks to allow for better positioning over cargo hatches. It gives more freedom in handling cargo than was possible with the conventional fixed position booms. The three forward cranes are electrohydraulic positionable units intended to operate as fixed cranes approximately 10 ft off the ship centerline. They may be moved from port to starboard across the ship, thus avoiding the necessity for duplicate units. Two cranes can be brought to bear on the large No. 2 hatch.

The two after cranes are of the Gantry type, spanning the hatches, and operating on fore and aft tracks to move up and down the ship. These cranes are fully mobile under load. Drives for the cranes are straight electric with magnetic controls on the luffing and hoisting.

New quick-acting, watertight mechanical hatch covers have been installed that can be opened and closed by the new cranes.

Conversion of the Nelson was done at a cost of $3,040,681. During sea trials a speed of 17.5 knots was reached.

GTV (Gas Turbine Vessel) JOHN SERGEANT—This ship has caused

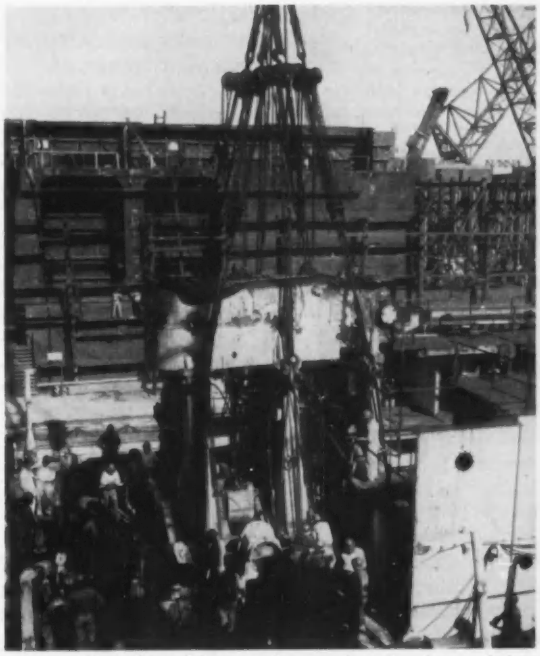


FIG. 2—The old triple-expansion engine is shown being removed from the John Sergeant. Engine throttle shaft can be seen leading from top of engine (far right near small circular flange) to wheel at bottom. When installed in the ship, the connecting rods and eccentric rods are exposed as shown here. Inlet steam pressure is 225 psi at about 450 F superheat.

FIG. 3—A new 6,000 hp gas turbine is being lowered into the John Sergeant's engine room. During the ship's sea trials it reached a speed of over 18 knots. Because of the engine's design, it was decided that a reversible pitch propeller was necessary. This permitted control of the ship from the bridge without reversing the direction of the engine.

FIG. 4—The S.S. Thomas Nelson had its engine replaced by two 3,000 shp diesel engines driving through a reduction gear. An 82.5 ft. section of the bow was removed to make way for the streamlined hull shown here. The result was an increase in length of 25 feet. The old steam cargo handling equipment has been replaced by the electro-hydraulic type shown. The cranes ride on tracks to give more freedom in cargo handling.

the greatest stir among shipping circles with its rotary compressor open cycle gas turbine power unit combined with 17.5 ft controllable pitch propeller. The hull of the Sergeant was lengthened similar to the Nelson's and its present cargo handling gear was retained.

The gas turbine in the Sergeant is the largest ever to go into a ship, and the first in a U. S. Merchant ship. In operation: air is compressed to 72 psi; heated in a regenerator or recuperator; then to the combustion chamber. The combustion gas passes through two independent turbine wheels, the first of which drives the compressor, and the second drives the ship's propeller through a reduction gear. To complete the cycle, the turbine exhaust gas passes through the low-pressure side of the recuperator, to heat the incoming compressed air. It then exhausts to the atmosphere through a waste heat boiler that provides small quantities of steam for heating, galley and miscellaneous purposes.

Additional features of the Gas Flow path include intake baffles to remove entrained salt water and an exhaust-gas-fixed superheater.

The Blades of the controllable pitch propeller may be reversed to obtain astern power for the ship without reversing the direction of rotation of the propeller shaft. This type of propeller has an infinite number of possible pitch settings between the limiting positions of full ahead and full astern, including zero pitch. Optimum settings will be determined by operation experience.

A shaft brake capable of absorbing 10 per cent of the normal continuous plant output 6000 SHP has been added by a modification of the main reduction gear casing. This permits low-power operation of the plant without propeller rotation, and gives improved dockside maneuverability.

On sea trials, the Sergeant reached a speed of over 18 knots at 7,575 shaft horsepower. Normal operations will be done at around 6,000 SHP to obtain a 15.5 knot speed. The ship did a crash stop from full speed ahead to dead in the water in two minutes, forty seconds, compared to seven minutes for a conventional power plant. The propeller can be completely reversed from the forward limit pitch to the after limit pitch in 17 seconds. Dual controls are installed so that emergency control of the propeller can be handled from the bridge of the ship.

Of interest to the shipping industry is the potential economies of the plant. Initial cost of a 6,000 ship gas turbine now runs about $140 a shaft horsepower compared with about $200 for a steam turbine. And, General Electric builders of the plant, say that if as many as 50 gas turbines of the Sergeant type are ordered, costs will drop to around $70 to $100 per shaft horsepower.

Fuel costs are less on gas turbines than on conventional plants; just how much will be determined after more sea time. But a feature of this type of plant is that it becomes more efficient in colder weather. The heavier density of the air makes the difference.

G.E. uses a break point of 80 F, and says that every degree below this can be multiplied by a factor of 40 to determine the increased efficiency. For example: at 40 F, the gas turbine would be burning fuel oil at a rate to produce 4,400 horsepower, but the engine would be producing 6,000 hp. Thus, daily fuel oil savings would run close to 35 to 40 barrels a day at this temperature. Figuring costs at around $2.70 a barrel, it makes a difference.

Other factors: a reduction of engine room crew to run the gas turbine will be possible; at least three men can be cut, maybe more (seaman's union willing); increased maneuverability with the controllable pitch propeller.

Conversion of the Sergeant was done at a cost of $3.4 million; the gas turbine cost around $900,000; and the controllable pitch propeller cost

$118,200. Sea trials were held in September. The United States Lines is operating all three of the ships.

SS WILLIAM PATTERSON—A free-piston generator gas turbine main propulsion unit will be installed in this ship, and will be the first application of this type of plant in a U.S. ship. The hull of the Patterson has been lengthened, and its existing cargo gear retained.

The potential use of free-piston generators with gas turbines in ships is rated high by the maritime Administration. Its over-all thermal efficiency promises to exceed that of any existing conventional ship's power plant. One practical advantage is that the required power can be obtained with various combinations of gas generators and different size turbine units. For mobilization purposes, it is desirable because very little critical material is required to mass produce the units because of their relatively low operating temperatures.

The free-piston principle is relatively new in the U.S., although it has been used extensively in Europe. Design of the plant has been made on the basis of original pescara patents by Sigma of France (Societe Industrielle General de Mechanique Appliquce) combined with Als-Thom Turbines.

In operation, six free-piston generators are combined with two turbines, reduction gear, propeller shaft, and propeller. Each gas generator has two opposing pistons in a single power cylinder. Combustion takes place in the cylinder on the two stroke Diesel cycle, and power is produced by the exhaust gases which drive the turbine before being discharged to the atmosphere.

Each gas generator has two air cylinders that serve as bounce or cushion cylinders. Large air pistons separate the two functional chambers.

The power or Diesel cylinder is in the center of each gas generator between smaller Diesel pistons. Like large Diesels, the free-piston engine is air starting.

Conversion of the William Patterson will be at a cost of $1,857,000. The power plant by the Cleveland Diesel Engine Div., of General Motors cost $1,228,723. The ship will be completed next month and may be operated by the Lykes Steamship Lines.

COMING EVENTS

NOVEMBER 13-14

Sixth Transport Aircraft Hydraulic Conference, Park Shelton Hotel, Detroit, Mich., under the sponsorship of Vickers, Inc., the program will follow topic suggestions from conference participants. Emphasis will be placed on original equipment hydraulic system design for the airframe manufacturer.

NOVEMBER 15-16

National Association of Corrosion Engineers, Hotel Statler, Detroit, Mich. Symposiums on the automotive, construction, chemical, utilities and power industries.

NOVEMBER 15-16

Tenth Annual Meeting of the Operations Research Society of America, Hotel Mark Hopkins, San Francisco. Sessions are being arranged on: Operations Research in Transportation; Operations Research in the Petroleum and Chemical Industries; Computers in Operations Research; Statistics and Decision Theory in Operations Research; Industrial Use of Military Operation Research Experience. For further information contact the ORSA, c/o Operations Research Office, Johns Hopkins University, 7100 Connecticut Ave., Chevy Chase 15, Md.

NOVEMBER 25-30

ASME Annual Meeting, Hotel Statler, New York City.

NOVEMBER 26-30

Twenty-second National Exposition of Power and Mechanical Engineering, Coliseum, New York City. During the week will be the 76th annual meeting of the ASME, including sessions of the Society's Nuclear Engineering Div. The 35th annual Atomic Energy in Industry Conference of the National Industrial Conference Board will also be held at that week.

NOVEMBER 26-30

Third International Automation Exposition, New York Trade Show Bldg., 500 Eighth Ave., New York City. There will be 180 exhibiting manufacturers and 60 lecture-demonstration clinics on computers, process automation, machine automation, servomechanisms, electromechanical and electronic components.

DECEMBER 10-12

1956 Eastern Joint Computer Conference, Hotel New Yorker, New York City. The meeting will be jointly sponsored by the IRE, AIEE, and the Association for Computing Machinery. The theme will be "New Developments in Computers." Besides an extensive program of technical papers, there will be many exhibits.

DECEMBER 19-20

Radio-Electronics-Television Manufacturers Association Symposium on Applied Reliability, Bovard Hall, University of Southern Calif., Los Angeles, Calif. There will be sessions on Mechanical Reliability, Information Feedback, and Component Evaluation Usage. Highlight of the meeting will be an evening panel session on "Failure Feedback—Is It Effective."

JANUARY 14-16, 1957

3rd National Symposium on Reliability and Quality Control in Electronics, Hotel Statler, Washington, D. C. The theme will be a "Report to the Nation on the Present Status of Reliability.

JANUARY 16-18

13th Annual National Technical Conference of the Society of Plastic Engineers, Hotel Sheraton-Jefferson, St. Louis, Mo. Theme of the show will be "Fifteen Years of Plastics Progress." Technical session topics are: Tooling and Machinery; Atomic; Design; Extrusion; Injection; Foams; Applications; Reinforced Plastics; Instrumentation; Compression Molding; Polyethylene; and Epoxy.

JANUARY 21-22

Solar Furnace Symposium, Hotel Westward Ho, Phoenix, Arizona. Session topics are: Design and Operation of Large Solar Furnaces; Furnaces for Basic and Applied Research; and Furnace Performance Determination and Control. Following the sessions will be a field trip to see a small furnace at the Arizona State College.

THE SHORTAGE OF SCIENTISTS AND ENGINEERS:

What Can Be Done About It?

There is no easy or quick way to overcome the shortage of scientists and engineers that has become a threat to our national security and economic progress. The solution can come only through diligent efforts extending over several years to bring the supply of technically trained people into balance with our needs. Meanwhile, the pressure of the shortage can be relieved if industry, government and education make better use of the limited number of scientists and engineers now available.

Earlier editorials in this series have discussed the dimensions of the shortage of technical manpower, its meaning for our national security and our economic well-being and the causes of the shortage. This final editorial will survey some of the measures that can be taken to overcome the shortage. Most of the proposals presented here have been suggested elsewhere. But in combination they appear to offer the best hope of an answer to this serious national problem.

Soviet Methods Not For U. S.

It is clear that no crash program, inspired by panic and designed indiscriminately to drive hordes of high school students into science and engineering, is suitable for the United States. Even if we adopted Soviet methods of channeling a large portion of our brightest young people into technical fields, it would be at least four years before results appeared in the volume of college graduates. And such an approach would do no credit to the American way of life.

Any crash program, whether it involved totalitarian methods or simply overselling the advantages of technical careers, would be objectionable for other reasons as well. It would jeopardize the quality of scientific and engineering training. It would put many young people in fields where they have little aptitude and deny them to other fields for which they are better equipped. And, if carried too far, it might even result in the overcrowding that was feared prematurely a few years ago.

The most important problems for the long run, as the preceding editorial in this series indicated, are in the area of education. Any real solution must reduce the loss of talented high school graduates who do not continue their education for financial reasons or because of lack of interest. Also, it must improve the quality of high school preparation in science and mathematics and, above all, relieve the critical shortage of teachers.

Basic Needs in Education

Substantial increases in salaries of teachers in most of the nation's school systems are essential if high school students are to receive adequate preparation for courses in science and engineering. Pay scales that have lagged behind rising living costs and salaries available in industry have placed great strain on even the most devoted teachers. There has been a sharp drop in the number of new graduates trained to teach science and mathematics, and of this smaller number many have decided not to follow careers in teaching.

Raising teachers' salaries to more realistic levels must be primarily the job of local school districts, aided by state governments. If, in face of rapid increases in school enrollments, local and state resources prove insufficient, then federal aid will have to be considered. Higher teachers' salaries, however financed, inevitably mean higher taxes. But without appreciable improvement soon, the quality of our entire educational system is in danger.

At the college level also, financial aid is needed to provide scholarships for promising students and to increase faculty salaries. (An earlier series of editorials dealt more fully with these problems, and business aid to higher educational institutions has been mounting at a gratifying rate.)

But not all the educational problems related to the shortage of scientists and engineers can be solved with money. Science and mathematics have steadily been de-emphasized as more youngsters have gone to high school for terminal education rather

How business is helping to relieve the shortage of technical manpower

Summary of a
Survey by McGraw-Hill Correspondents

Sponsoring summer study programs for high school teachers
Arranging cooperative work-and-study programs for students
Sponsoring college fellowships and scholarships in science and engineering
Paying tuition of employees taking science and engineering courses
Keeping college faculties abreast of new developments in industry
Hiring high school science teachers for summer and part-time work
Giving old, but usable, laboratory equipment to schools
Cooperating in high school science exhibits
Sponsoring regional science fairs
Sending speakers and training aids to schools
Opening plants for student tours
Analyzing jobs to relieve engineers and scientists of routine work

The McGraw-Hill Department of Economics will be glad to hear of any other ways business is helping relieve the shortage.

than for college preparation. This de-emphasis must be reversed.

Techniques of instruction, furthermore, can stand improvement at all levels of education. Professor E. P. Northrup of the University of Chicago observes: "In the past fifty years . . . there has been a revolutionary change in the character of mathematics, yet not a trace of this change is to be found in the curricula of all but a handful of secondary schools throughout the country." Colleges and universities may have to examine old fetishes about light teaching loads and small classes in order to make more efficient use of their faculties.

What Industry Can Do

Industry has the immediate problem of better utilization of available technical manpower and the long-range responsibility of helping increase our resources of trained people. Frantic recruiting practices and reckless bidding up of starting salaries—financed largely by government money for defense orders — are not the answer. There is need for earnest consideration of incentives for experienced scientists and engineers, who too often must look to sales or executive positions for adequate financial recognition.

Industry in many instances could make more efficient use of engineers and scientists by shifting work to technicians, clerical personnel and even machines. One company found that 15% of the time of an engineering design group was spent on routine jobs and that this valuable time could be saved by adding a technician and a clerical worker to the group.

Other potential sources of technical manpower could be tapped more extensively to relieve the shortage. Very few women have entered what has been traditionally a man's world. Negroes are only slowly gaining educational and employment opportunities in technical fields. And many experienced older men can still give useful service.

A Good Beginning

Much is being accomplished already in efforts to attract more young people into scientific and engineering careers. A summary of some of the things business is doing is presented above. Other notable contributions are being made by such organizations as the professional engineering and scientific societies (especially through their manpower commissions), the National Science Foundation, the National Research Council, the National Education Association, the National Merit Scholarship Foundation and the Thomas Alva Edison Foundation.

Results are beginning to appear in rising enrollments in engineering schools and technical institutes. Between 1951 and last year, according to McGraw-Hill's annual survey of technical institutes, enrollments in these schools rose from 46,000 to a record 67,000. Engineering enrollments rose in the same period from 166,000 to 243,000. A rising tide of graduates is already being made available to American industry.

This is a good beginning. But only with wider appreciation of the serious implications of the shortage of scientists and engineers and intensified efforts on the part of business, government and education to relieve the shortage can we hope to overcome this threat to our national security and economic well-being.

This is one of a series of editorials prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments of particular concern to the business and professional community served by our industrial and technical publications.

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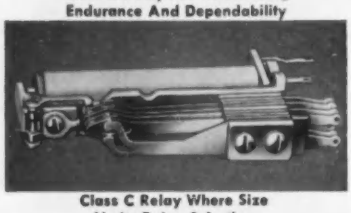

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Class A Relay When First Cost Is Important

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GENERAL TELEPHONE SYSTEM

Designing Beams for Shock and Vibration

J. J. KERLEY, Jr.
Structural Engineer, Westinghouse Electric Corporation
Air Arm Division

MOST STRUCTURAL FAILURES IN MODERN EQUIPMENT are caused by shock and vibration rather than by steady-state loads. Numerical methods and techniques are available to analyze these structures. However, in most problems a detailed analysis is both unnecessary and inefficient when the natural frequency can be determined graphically. The accompanying nomograph will help determine the natural frequency of various types of beams.

In designing for shock and vibration, there are two possible courses of action. One method is to design the basic structure as stiff as possible and keep the natural frequencies of the structural elements high. With such construction, structural damping is usually low and most of the vibration and noise is transmitted directly to the isolator. This stiffness and high transmissibility is too difficult to be overcome with some mounts, and a high damping alloy that has both high strength and good damping qualities may have to be used. (See "Manganese-Copper High-Damping Alloys," May 1956 page 135.)

Another method is to design the basic structure with flexible construction, such as the use of sheet metal for electronic equipment. This gives lower natural frequencies. Flexible structure elements will reduce high frequency noise but magnify the low frequency elements.

If the basic structure is too limber, its natural frequency may be in the vicinity of the natural frequency of the isolator and unsatisfactory performance results with built-up of magnification. Thus for efficient shock and vibration control, the following basic considerations should be applied:

1. **Be consistent.** If the design is stiff, make it all stiff. If limber, it is of little advantage to throw in several stiff members.

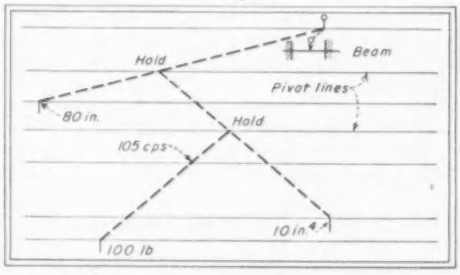
2. **Avoid stress concentration points** by having a gradual transition from loose to stiff sections or vice versa.

3. **Supporting structures should not have the same major natural frequency as the isolator.** A general practice is to have every structural element on the isolated structure with a natural frequency at least one and a half times greater than the natural frequency of the mount.

4. **Avoid isolators with natural frequencies of exciting forces** such as the chatter frequency of hydraulic mechanisms, periodic frequency of firing guns.

The nomograph on the next page can be used to compute the natural frequency of basic structural elements when their length, weight, and moment of inertia are known. Examples below show the three steps required.

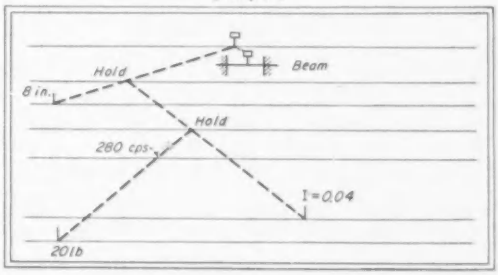
Example 1



Given:
1. $E = 30 \times 10^6$ (steel) psi
2. Beam: Double end fixity
3. $I = 10$ in.^{4}
4. $l = 80$ in.
5. $W = 100$ lb

Answer = 105 cps

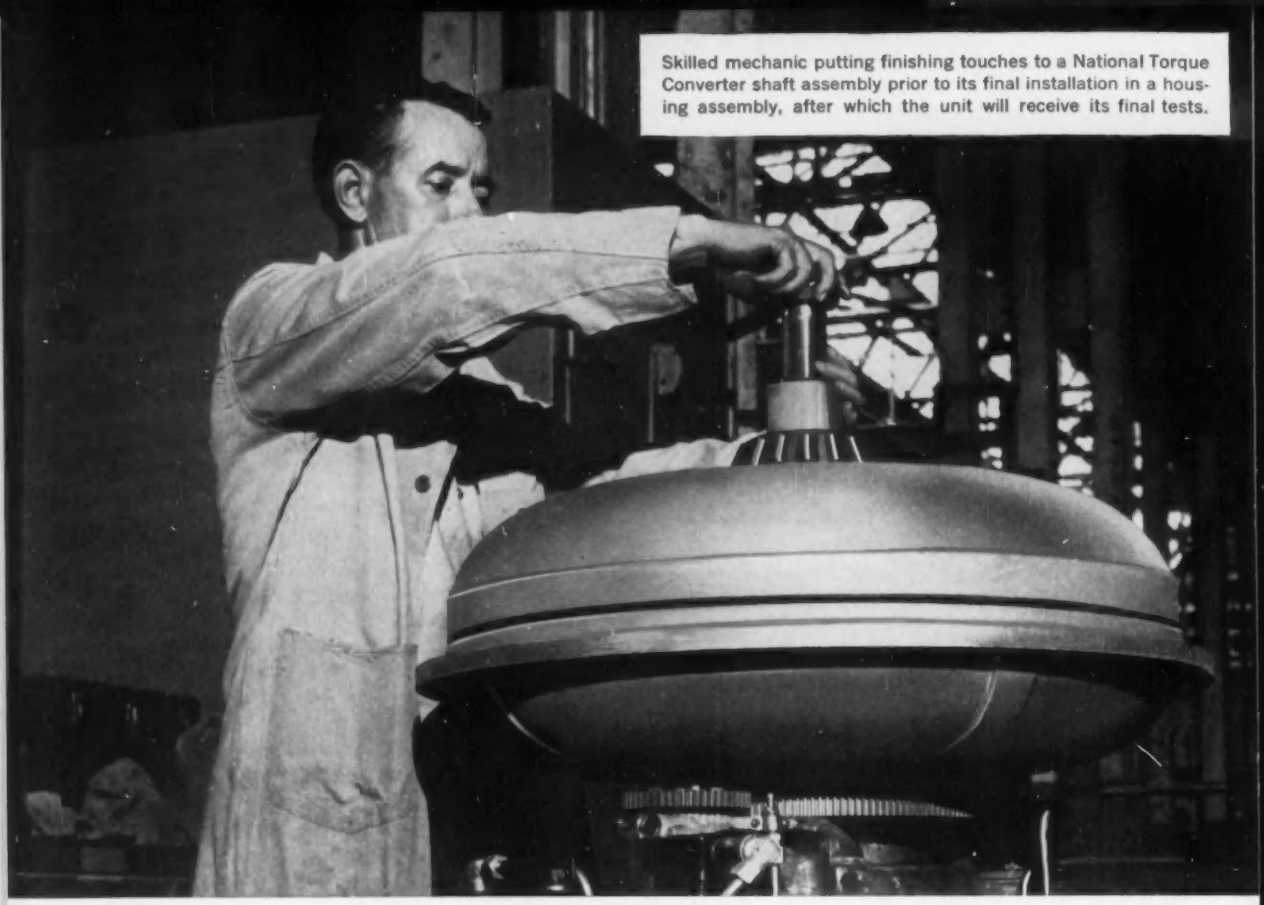
Example 2



Given:
1. $E = 10.5 \times 10$ (alum.) psi
2. $I = 0.04$ in.^{4}
3. $l = 8$ in.
4. $W = 20$ lb
5. Double end fixity
6. Aluminum

Answer = 280 cps

(continued on page 223)



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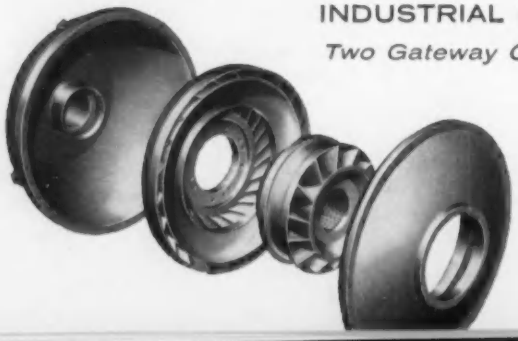
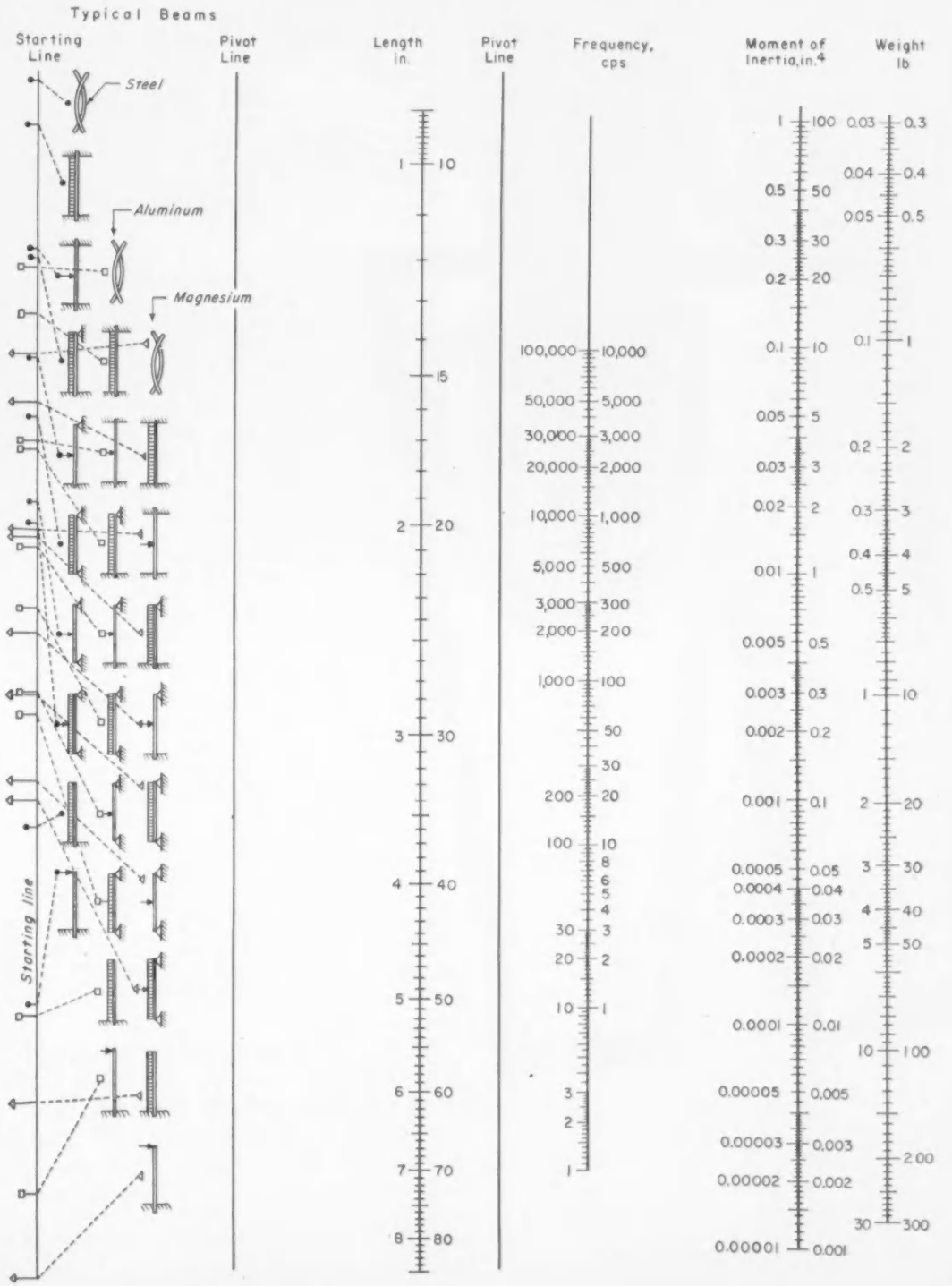


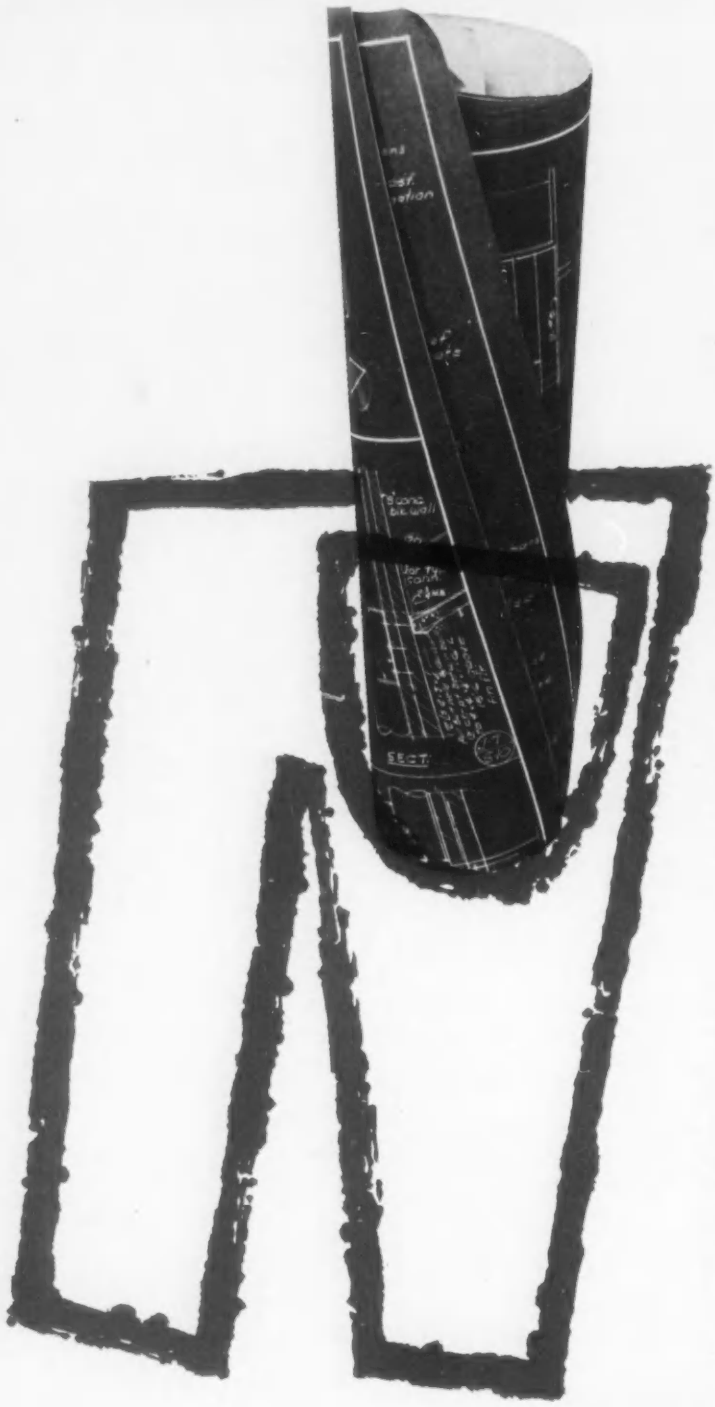
Pace-setters in the progress of industrial power transmission

PRODUCT ENGINEERING - REFERENCE BOOK SHEET

Designing Beams for Shock and Vibration (continued from page 221)

Nomograph for Determining Natural Frequency of Beams





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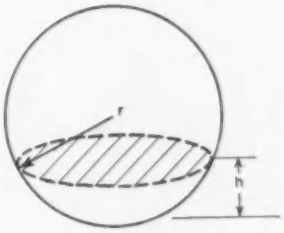
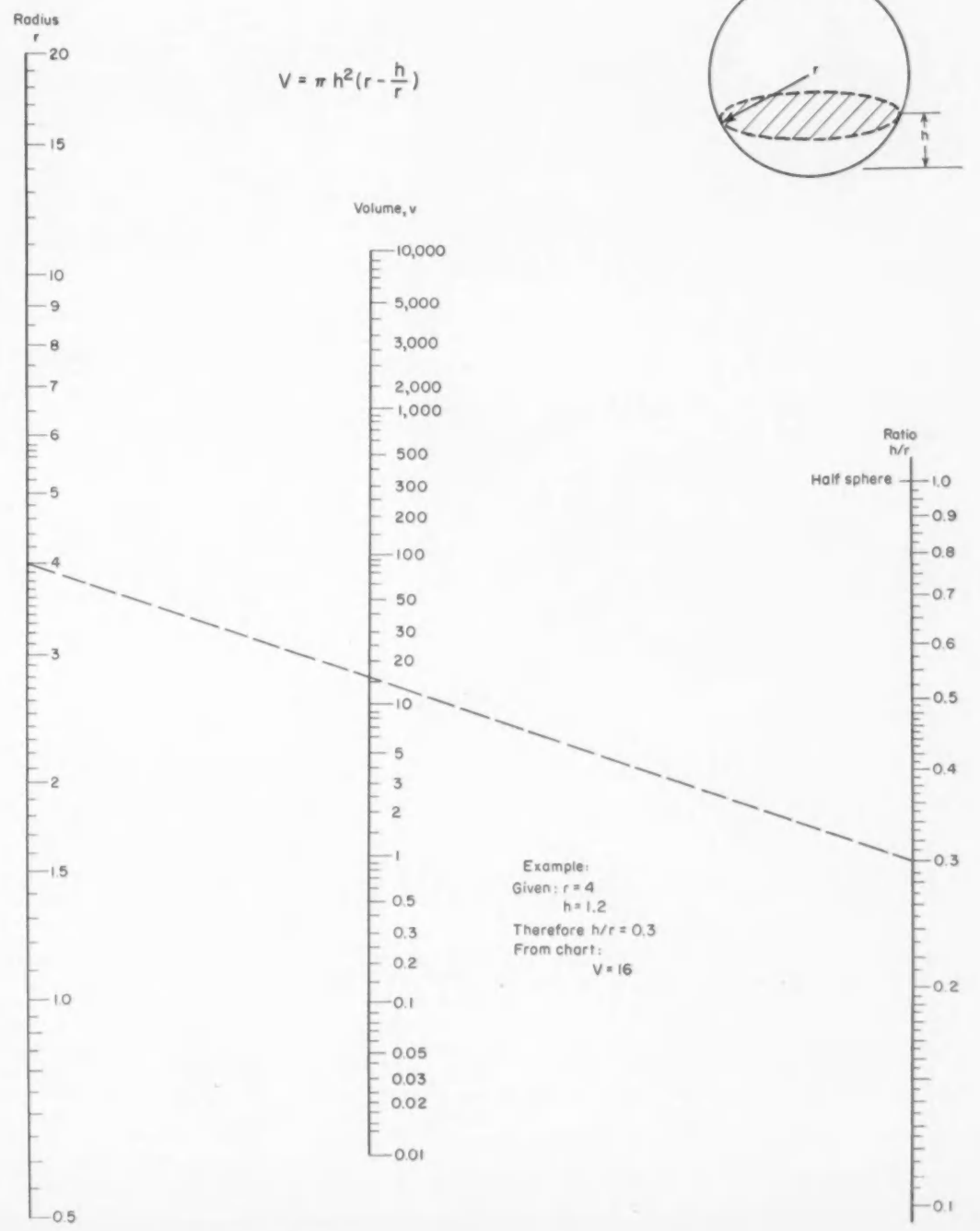
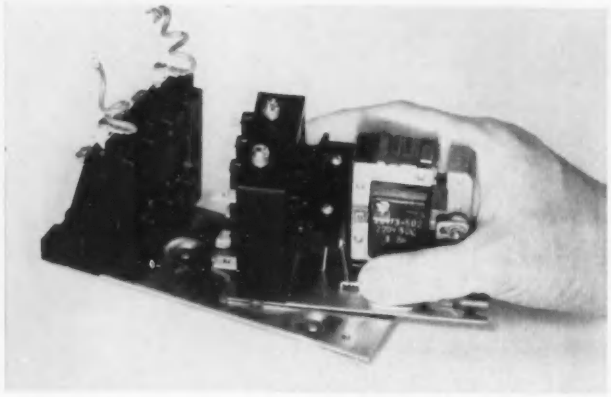
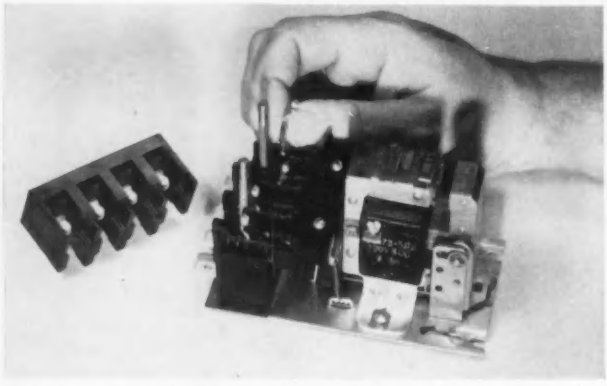
$$V = \pi h^2 \left(r - \frac{h}{r}\right)$$



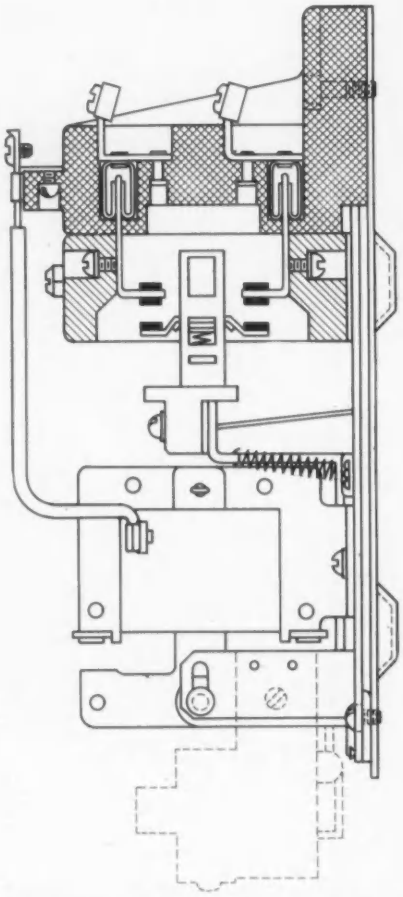




PLUG-IN RELAY uses same base, contacts and coils for all convertible units in line. Made in No. 0 and No. 00 sizes, rated at 10 and 15 amp.



SILVER-CADMIUM CONTACTS are removed without tools, for maintenance or when converting from normally open to normally closed arrangement. All contacts are visible at all times, even in service.



ARRANGEMENT OF PARTS and dimensions shown in this side view of relay remain the same for all models.

Plug-In Industrial Relays All Use Same Basic Parts

Designed for heavy duty service on machine tools and other high production machinery, this line of contactors has a contact arrangement and plug-in construction that is said to reduce down-time and simplify maintenance. The relay is convertible from normally open to normally closed circuits, using the fingers alone to re-position the contacts after the top of contact housing has been removed. All contacts are visible at all times, even when the unit is fully assembled and in service.

For servicing, cleaning or replacement of coil or contacts, the contactor assembly, solenoid-type magnet and latching accessory (when used) can be unplugged and a replacement unit inserted immediately. Only the two screws securing these components' mounting bracket to the base plate need be loosened to accomplish this. No wire connections need be disturbed—even the solenoid coil can be included in the plug-in base plate need be loosened to accomconnections, if desired. Standard basic relay is adaptable to plug-in arrangement, operable with or without plug-in parts.

Again only two screws need be removed to replace the coil or the

contact points. Stocking of replacement coils, points and other parts is simplified by the use of the same coil and points for all the starters in this new line. The same basic parts does for all models also, providing uniform length and height dimensions, regardless of rating. Only the width varies, depending on the number of poles.

Use of the same magnetic coil for all models of the relay is made possible by an adjustable spring assembly and the knife-edge-type mounting of the moving-contact assembly This section is easily positioned in an intermediate position with all contacts disengaged, if servicing without removing plug-in section is desired. Release from the intermediate position is automatic upon energization.

Latching of the new contactor is accomplished with an accessory latching unit, which mounts by means of two screws on the magnetic coil's bracket. Operation is by a separate solenoid, and while normally supplied as a latching-in unit, the latch can be converted to latch-out by detaching spring and reversing wedge.

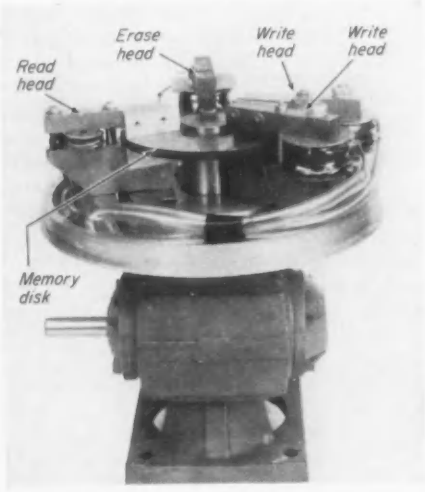
Both No. O and No. OO sizes are available in the new relay, rated at 10 and 15 amp, 600 v max. Coils are rated at 5.6 w. Dimensions are 3 in. deep, 7⅛ in. long. Width ranges from 2 to 6 in., depending on number of poles.

Temperature rise in the new contactor's coil is 27 C above room temperature after 6 hr continuous operation. Temperature rise for contacts is 31 C. Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford 6, Conn. For more information—Circle 1, inside back cover

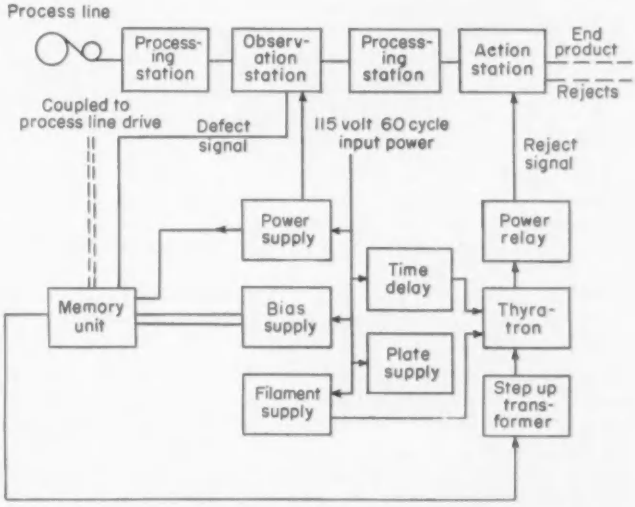
Magnetic Memory System Gives Delayed Signals

A magnetic memory system originally designed for delayed control of high speed continuous process lines and automatic sorting of items moving through complex conveyor systems is for applications where automatic measurements can be employed to control subsequent operations. In one continuous process, for example, a photocell might be used to measure off-color areas in cardboard strip. Thereafter the strip is printed and then cut for carton blanks. This new memory system will remember the location of each defective area and cause the sorting mechanism to pull out all defective blanks. This function is performed at all line speeds from zero up. Variations in speed of the conveyor, including starting and stopping of the line, do not disturb the correct timing of the sorting action, according to the manufacturer.

Measurements to be remembered are used to magnetize narrow sectors of a hardened steel disc. The disc rotates in synchronism with the machinery or line being monitored. The measurements are then read off the disc at the same time the mate-



MEMORY UNIT has a 4-in. dia disc for storing signals and gear box is coupled with system drive.



Memory system applied to a typical processing line installation.

CONTINUED ON PAGE 228

rial that was measured reaches the action or sorting points. The read-out is accomplished no matter how slow or fast the line is moving—even if the line is stopped. After read-out the disc is erased and is ready for re-use.

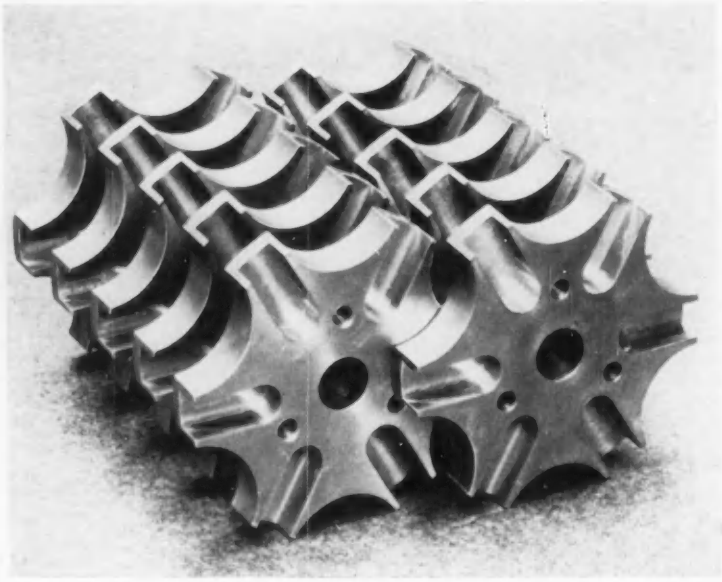
Signals are accepted from almost all measuring devices, such as photo-electric controls, pressure switches, relays, beta gauges, ultrasonic detectors, magnetic detectors. No exact gearing or coupling ratio need be prescribed between the processing or conveyor line drive shaft and the input shaft.

Any number of measurement stations may be added on a processing or conveyor line. Only 3 deg on the memory disc are required for a single signal.

Power requirements are 110-120 v at 60 cps, 40 w. Electrical input to switch of 0.5 amp at 8 v d-c is needed. Mechanical input is best provided by a gear box. Output signal is provided by a 10 amp resistive load relay. Dimensions aind weights are: memory unit, 9½ x 8 in. high, 20 lb; control unit, 9½ x 12¼ x 20¼ in. high, 28 lb. Minimum spacing between signals on disc is 3 deg.

Automation, Inc., 212 Worcester St., Wellesley Hills 82, Mass.

For more information—Circle 2, inside back cover



Geneva Movements

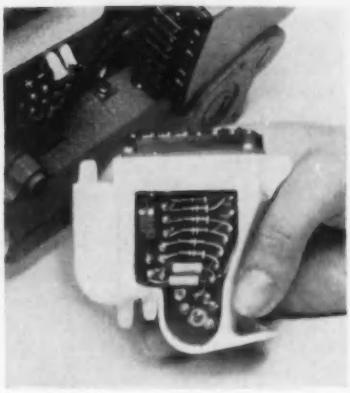
To provide a way of converting rotary to intermittent or indexing motion, these units are made with three, four, five, six or eight indexing stations with any hub, bore and key-way combination desired, including ball-bearing mounting. They are used in packaging, chemical, food-processing, armature winding, cutting tool, metal sintering, automotive, and other machinery that involves automatic positioning.

Drives, in any number of points, are made with wheel outside diameter from as small as a dime to 20 in., in mild steel or heat-treated machinery steel. Genevamatic Engineering Co., 400 E. Ellamae, Tampa, Fla.

For more information—Circle 3, inside back cover

Timing Pulse Generator

A timing generator which can be designed to pulse at any rate from 1 to 3000 times per second, weighs 2¼ oz and occupies 4 cu in. The unit has been successfully installed as an integral part of an airborne recording camera. Developed by Missile Systems Div., Lockheed Aircraft Co., the device is being manufactured by Electromation Co., 116 S. Hollywood Way, Burbank, Calif.



For more information—Circle 4, inside back cover

Liquid Pressure Pickup

This device will measure dynamic pressures, which may consist of complex waves from sonic vibrations, blast pressures, and water hammer in liquid-filled lines. Dynamic pressure applied to the diaphragm of a sealed, liquid-filled cell causes an infinitesimal amount of polar liquid to flow through a porous disk, generating an electrical signal. This electrokinetic effect is known as the "streaming-potential" phenomenon.

About 1 in. thick and 1⅞ in. dia, the pickup will operate at a pressure range of 10^{-4} to 100 psi and temperature range of −10 F to 140 F. The unit will respond "flat" between 3 and 2500 cps. Pressure oscillations in this frequency bracket will produce electrical signals that are in phase with and proportional in amplitude to the pressure.

After temperature cycles, pressure

CONTINUED ON PAGE 230

The Engineer from Continental Screw Co. ...

... is specially trained to analyze your special fastener needs

Continental Screw leads entire industry in production of special fasteners

Continental is the only screw manufacturer that requires every engineer to have specific experience in the production of ground thread taps and gages. Continental knows that special training in this exacting field is necessary to give each job the skill and understanding it requires.

As a result of this specialized training, Continental produces more special fasteners than any company in the field. Over 6,500 different blueprints are turned out each week by Continental engineers. And the degree of accuracy is so great that Continental cold-forged fasteners are daily replacing expensive screw machine products, improving the product by increasing its strength while reducing its cost.

Why not put your special fastener needs in the most experienced hands. Continental's specially trained engineers are always ready to analyze your particular fastener needs. Call Continental today.

CONTINENTAL INC. ★ 1904 ★ SCREW COMPANY

You Can Always Count on Continental

Continental Screw Co.

Manufacturers of Holtite Fastenings

New Bedford, Massachusetts, U.S.A.

cycles, shock and vibration, the pickup is said to retain its calibration. Internal impedance (100,000 ohm) is lower than that of piezoelectric-type devices used in similar work. The output is described as high. If a 100 psi oscillating pressure is applied, for example, the open-circuit output will be approximately 35 v. With this high output almost any type electronic device can be used with it, providing proper impedance-matching is achieved. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

For more information—
Circle 5, inside back cover

Fasteners with Curved Tool Recesses

For screws, bolts, blind bolts, cowl fasteners and other turning types of fasteners, the recess consists of a slot undercut on both sides and with driving surfaces parallel. A circular, or disc-shaped, driver blade is used. These innovations are said to result in full bearing thrust of the driving blade against the driving surfaces, elimination of the camming action which tends to force the blade out of the slot, plus longer driving blade life.

Special sizes are available on request and all types and sizes are available in such materials as alloy steels, stainless steels, Ascolloy, A-286 and titanium. Pheoll Mfg. Co., 5708 Roosevelt Road, Chicago 50, Ill.

For more information—
Circle 6, inside back cover

Solders Containing Indium

Indium is said to make solder harder and stronger, and it becomes more resistant to corrosion. With varying amounts of indium, the properties of solder will also vary. For example, when a 12 indium—44 tin—44 lead alloy is compared with a 25 indium—37½ tin—37½ lead alloy, it is found that the solder which is richer in indium has a higher bonding-holding strength, while the lower indium content solder is harder, higher melting and has better electrical conductivity and tensile strength.

Twelve different alloys bearing indium are supplied, with melting temperatures ranging from 243 to 599 F. Alpha Metals, Inc., 56 Water St., Jersey City, N. J.

For more information—
Circle 7, inside back cover

Vapor Pressure Temperature Regulator

A self-actuated temperature regulator provides control for installations where danger of overheating, product spoilage or equipment damage is possible. Components include an extra-powerful bellows actuator connected by capillary tubing to a temperature-sensitive bulb. The actuator is mounted on top of a yoke connected to the valve. The bellows supplies the power for controlling the valve opening in response to the temperature changes at the bulb.

The bulb is placed in the tank or other location where desired temperature is to be maintained. The valve is

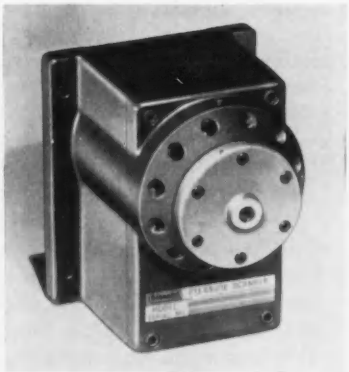
installed in the pipe line supplying steam, water, gas or other fluid to be used for heating or cooling. Klipfel Valves, Inc., Hamilton, Ohio.

For more information—
Circle 8, inside back cover

Pressure Scanner

Designed to permit measurement of up to twelve pressure sources with only one transducer, this device can be used to introduce automatically calibration and/or zero pressures during each scan cycle, permitting calculation of exact transducer response and greater accuracy. The transducer is vented to atmosphere between pressure ports, eliminating transducer hysteresis effects.

Basically, the device consists of a stator having 12 input ports, and a rotor that connects any one of the twelve input ports to an output port. The rotor is rotated to a desired position by a unidirectional high-torque motor, whose operation is controlled by means of a positive positioning arrangement. A relay circuit is incorpo-



CONTINUED ON PAGE 232

good start

CMP
RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL
Processed to meet special gauge tolerances and provide special finishes and physical properties . . . solves many fabrication, cost and performance problems.

In figuring production costs, a metal fabricator has the right to depend on good performance with the product of the strip steel supplier of his choice. To insure the performance needed to provide the best end-product cost, it sometimes pays to buy restricted specification cold rolled strip steel. Although the initial cost might be somewhat greater per ton of steel, many examples can be cited to illustrate the economy in such a practice when end-product costs are facts and not estimates.

Consider the case of the West Coast manufacturer who was purchasing coil stock (sold as cold rolled strip steel) for a forming operation where close gauge tolerance was not of greatest importance. (However, the drawing quality, because of chemistry, was not uniform and die costs and rejects were causing expensive down time and yield losses.) Switching to a **CMP** restricted specification strip, the manufacturer obtained a uniformity in coil after coil that eliminated these problems and provided an end product cost much below his former cost even though his initial steel costs were higher.

For a better finish, both on the product and on the cost records, it will pay you to check your requirements with **CMP.**

CMP
WHERE YOU CAN GET SPECIFIC SPECS. FOR SPECIFIC JOBS

LOW CARBON
HIGH CARBON
Annealed or Tempered
STAINLESS
ALLOY
ELECTRO ZINC COATED

THE COLD METAL PRODUCTS CO.
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, IND.
SALES OFFICES: NEW YORK CLEVELAND DETROIT INDIANAPOLIS CHICAGO LOS ANGELES SAN FRANCISCO

C M P

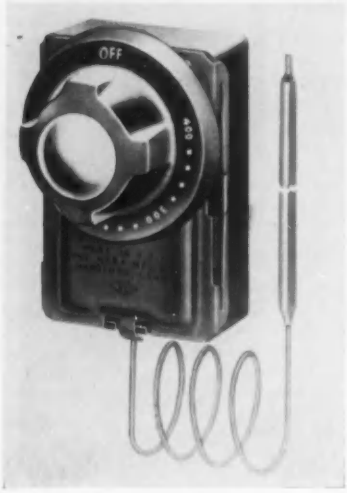
CMP STRIP PROVIDES
Increased production, reduced slow-downs, lower die costs, meets feed and speed requirements of automatic equipment and yields more finished parts per hundred pounds.

better finish

rated in the unit to provide dynamic braking in order to stop the motor in a position where the rotor and stator ports are in coincidence. An additional bank of contacts is provided on the internal switch so that indication of the rotor position can be obtained either visually (lights) or digitally for operation of recording devices.

The pressure unit will operate over a range of 0.1 to 350 psi and can be used for dry air and non-corrosive dry gases. Basic dimensions are 6⅜ x 5¼ x 5½ in., and the unit is adaptable for either panel or bulkhead mounting. Datex Div., G. M. Giannini & Co., Inc., 1307 S. Myrtle Ave., Monrovia, Calif.

For more information—
Circle 9, inside back cover

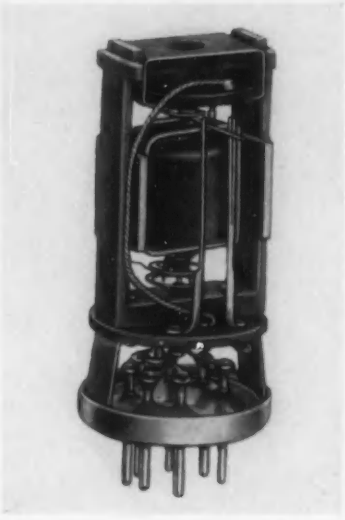


Thermostats Rated At 25 Amp

These thermostats are for range oven, industrial and air conditioning applications. Oven thermostats have UL-approved ratings of 25 amp, 120-240v a-c only, and a standard temperature range of 200 to 500 F with other ranges available to meet special requirements. They include two and three-position units, as well as single dial units both with or without automatic preheat operation.

Industrial models are designed for such applications as laboratory equipment, platens, steam tables, oil baths, grease kettles, coffee urns, blueprint machines. Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn.

For more information—
Circle 10, inside back cover



Miniature, Hermetically Sealed Relay

For applications where compactness and light weight are essential, or where external electromagnetic effects must be held to a minimum, this relay is housed in a tinned brass case. It is supplied for miniature seven-pin socket operation or with curved terminals for solder connection. For maximum shielding, Mu-metal cases can be furnished. Ranges and contact adjustments are available to order. Sensitivities are as high as 50-0-50 micro-amp at a coil resistance of about 2300 ohm.

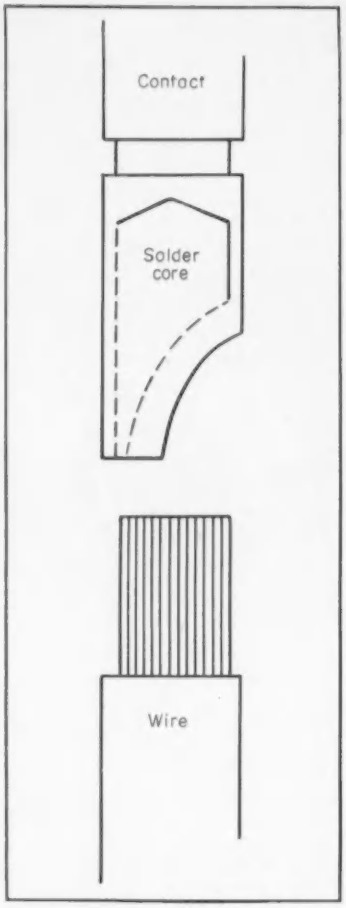
Non-magnetic contacts carry 35 milliamp at 6v d-c, non-inductive at high sensitivity, while loads up to 0.5 amp at 28v d-c, non-inductive, can be handled, depending upon the moving coil sensitivity and number of operations. High and low contacts can be arranged for zero center, single-pole, double-throw operation or suppressed zero with one contact normally closed. WESTON Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

For more information—
Circle 11, inside back cover

Transparent Tape

A transparent, pressure-sensitive tape for business and industrial uses has a polyethylene-surfaced cellulosic backing. At present it is available in the most popular sizes of ½ in. wide rolls, 2592 in. in length. General Tape Corp., First National Bank Bldg., St. Paul 1, Minn.

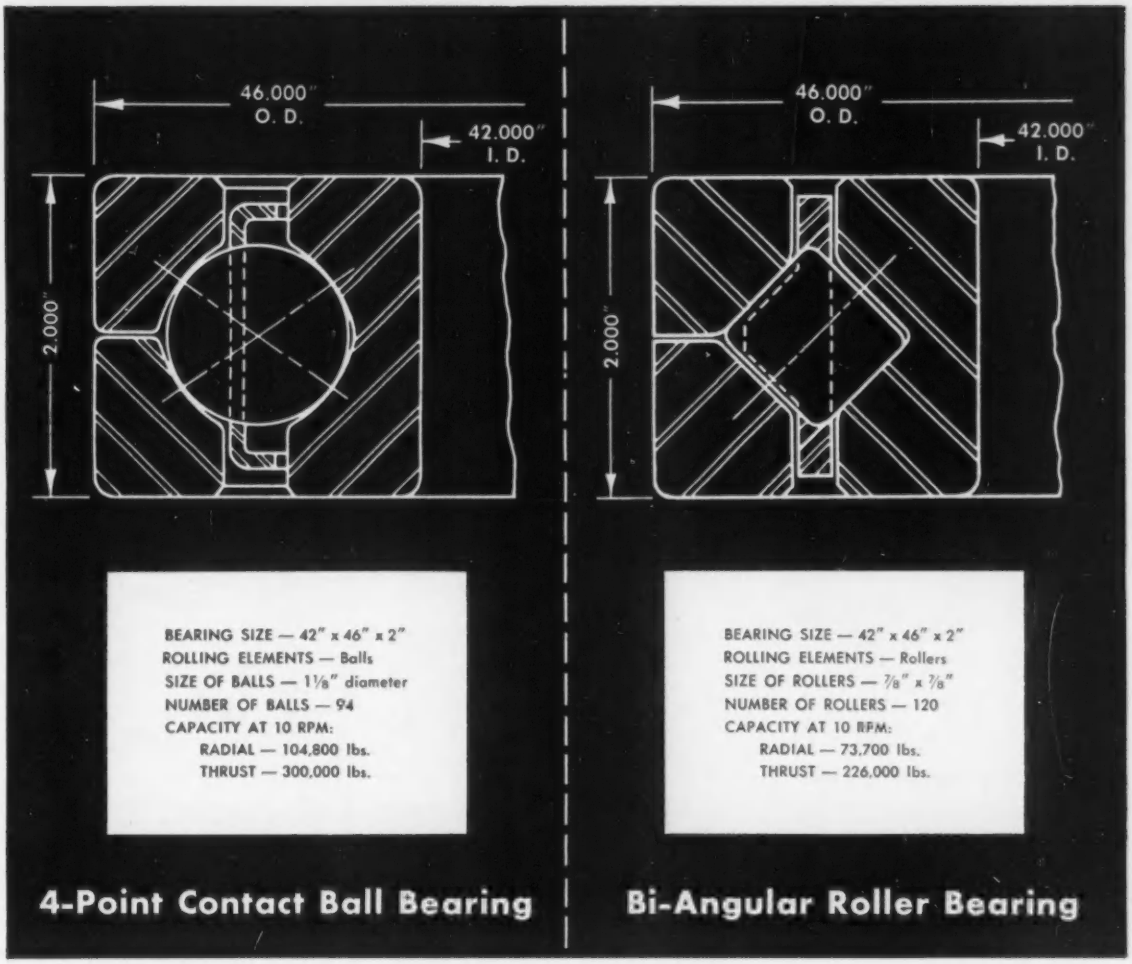
For more information—
Circle 12, inside back cover



Connectors with Solder-Filled Contacts

A line of miniature and subminiature connectors now comes with each pin and socket contact pre-filled with a solder alloy of any specified composition. The amount of solder provided is automatically controlled. To

CONTINUED ON PAGE 234



SURE we make both, but we recommend only one

Yes, Kaydon manufactures both — 4-point contact ball and bi-angular roller bearings in the same diameters and widths. BUT—we would in almost every instance recommend the former. Why? Because our field application reports consistently prove that the 4-point contact ball bearings are better for most applications than the lower capacity bi-angulars *(See capacity figures in drawings above.)*

Another important difference between the two bearings is that the 4-point contact ball bearing *is not limited to low speeds*, whereas the bi-angular normally should not be used above 10 rpm and usually is suitable only for oscillation. Then, too, the torque in the 4-point contact ball bearings is generally much lower.

Kaydon's unbiased recommendations result from years of bearing design, application and manufacturing experience with *all types* of ball and roller bearings up to 124" in diameter. So, why not contact Kaydon first?

K-563

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter ... Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

assemble, heat is applied to the solder clip and the wire inserted. A non-corrosive resin flux in solidified form on the surface of each solder cup eliminates the need for adding flux during the soldering operation. The manufacturer claims this method resists internal tarnishing and eliminates costly tinning. DeJur-Ansco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 13, inside back cover

D-C Power Supply

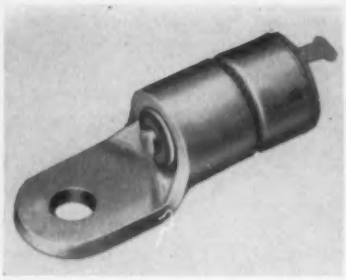
An adjustable output, constant voltage d-c power supply combines a constant voltage transformer, a germanium rectifier, and a special high-capacitance filter section with small choke. Output voltage is regulated within ±1 per cent with supply voltage variations up to ±15 per cent. Ripple voltage is held within 0.10 per cent (rms) at full load and nominal input voltage.

The power supply is available in six stock models that provide output adjustable in different voltage ranges between 5 to 400v, and currents up to 7 amp. All six assemblies are arranged for relay rack mounting on standard, 19 in. frame. Sola Electric Co., 4633 W. 16 St., Chicago 50, Ill.

For more information—
Circle 14, inside back cover

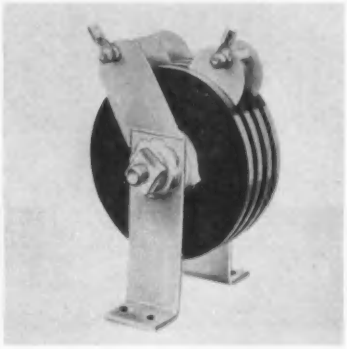
Terminal for Aluminum Wire

The terminal barrel contains a cartridge with oxide-removing compound that is sealed with a removable plastic plug. The tongue end of the barrel is provided with an inspection hole to ascertain if leads are fully inserted.



This inspection hole is equipped with a plastic sealing plug. The terminal is made of tin-plated aluminum and is designed to accommodate wire sizes No. 8 through 4/0. Aircraft-Marine Products, Inc., Harrisburg, Pa.

For more information—
Circle 15, inside back cover



Discharge Varistor Assembly

This voltage sensitive nonlinear resistor is designed for use in protecting motors, generators, lifting magnets, magnetic chucks, solenoids, relays, large coils against high inductive surges, resulting from sudden interruption of inductive currents. Manufactured in ready-mounted groups of one to four varistors, each varistor disk is 6 x ⅜ in. thick, with a 1 in. central mounting hole.

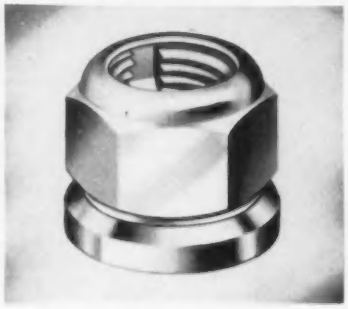
Disks are bracket-mounted on a horizontal insulated bolt with a spring lock washer to provide contact pressure. Spacers are included to permit air circulation. General Electric Co., Detroit 32, Mich.

For more information—
Circle 16, inside back cover

Self-Sticking Diagrams

These adhesive-backed labels can be applied directly to glass, metal, wood, plastic or painted surfaces and quickly applied with finger pressure. Uses for these labels include assembly instructions, guarantees, tube layouts, lubricating instructions, operational directions, maintenance schedules, jobber and repair depot locations, nameplates. W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.

For more information—
Circle 17, inside back cover



Self-Locking Washer-Nut

This all-metal self-locking nut has an integral washer and is expected to prove particularly useful for keyhole-type-flange mountings, including generators, starters, alternators, or any application where a washer-faced locknut is required.

The washer-nut is manufactured of C1137 steel, cabmium-plated in sizes ¼-28 to $\frac{7}{16}$-20, and is recommended for use at temperatures up to 550 F. Delron Co., Inc., 5224 Southern Ave., South Gate, Calif.

For more information—
Circle 18, inside back cover

Interval Timer

The case acts as an enclosure and insulator while providing substantial support for the switch blades. The plated steel cover does not require clearance holes and can be flush mounted to any surface.

Although rated at 25 amp, 250 v, and designed specifically for high capacity electrical appliances, the Model

CONTINUED ON PAGE 236

Using

DU PONT ELASTOMERS

NEOPRENE • HYPALON®

in Design

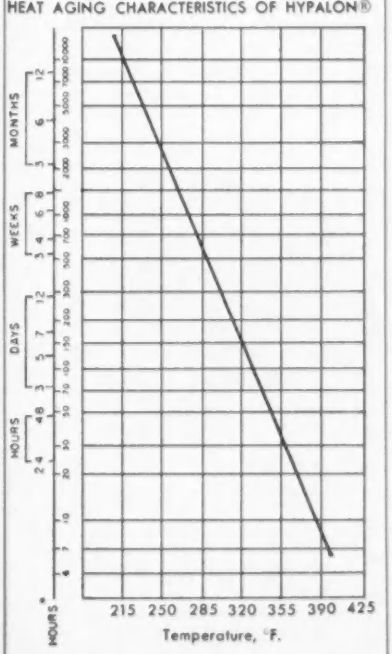
HYPALON® products have exceptional heat resistance

Compared to other kinds of rubber, HYPALON shows unusual resistance to hardening at elevated temperatures (250°-350°F.). This means an extra-long service life for HYPALON belts, hose, gaskets and other products which are used where heat is a problem.

The graph below is indicative of HYPALON's heat-aging characteristics. It shows, for example, that HYPALON compounds will retain 100% elongation after three weeks' *continuous* exposure at 285°F., three months at 250°F. and almost a year at 212°F. Longer service life naturally can be expected where temperatures are intermittent, or where air cannot get at the product—in a gasket, for example.

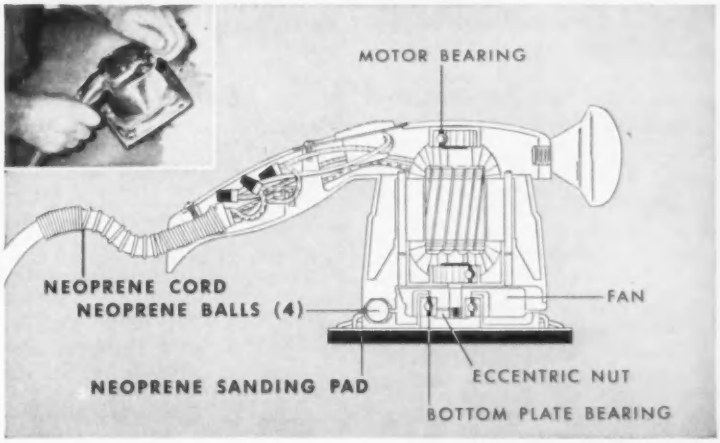
Other advantages of HYPALON include outstanding resistance to weather and oxidizing chemicals, *complete* resistance to ozone and the ability to be compounded in a wide range of light-fast colors.

HEAT AGING CHARACTERISTICS OF HYPALON®



*Exposure time in which elongation dropped to 100%.

Over 200,000 sanders in service—and manufacturer has yet to replace one NEOPRENE part



Low-cost neoprene ball bearings last life of sander... resist abrasion, solvents

Since 1950, a manufacturer of sanders has sold 200,000 units—each with a neoprene sanding disk and a system of neoprene ball bearings. Not one of these neoprene parts has required replacement in that time.

Ingenious use of neoprene

The sander's design is shown above. An eccentric nut attached to the motor shaft imparts a circular motion to the plate that holds the sanding pad. Between this plate and the motor housing are four ½" neoprene balls—one at each corner and each confined in a cavity of 19/32".

These neoprene balls transmit vertical force from the sander to the surface being sanded. They also act as roller bearings as the sander revolves. Finally, thanks to neoprene's resilience, they serve as shock absorbers—minimizing noise and vibration.

Neoprene beats competitors

The manufacturer tested many materials for the balls. Steel balls were noisy and wore out quickly. Natural-rubber balls deteriorated within three weeks when exposed to paint solvents in wet sanding. In the same tests, however, neoprene resisted abrasion and solvents for nearly a year.

Basing his judgment on these tests, the manufacturer chose neoprene not only for the bearing balls but also for the pad to which the abrasive paper is attached. And as a further improvement, neoprene-jacketed cord was also adopted.

DU PONT
REG. U.S. PAT. OFF.

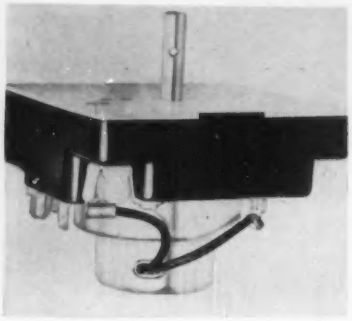
HYPALON is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further literature and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. PE-11
Wilmington 98, Delaware

Name_____ **Position**_____
Firm_____
Address_____
City_____ **State**_____



102 timer may also be used on low capacity appliances, semi-automatic washing machines, heater-fan controls, or wherever an appliance or machine must be controlled for a pre-set period of time. Controls Co. of America, Soreng Div., 9555 Soreng Ave., Schiller Park, Ill.

For more information—
Circle 19, inside back cover

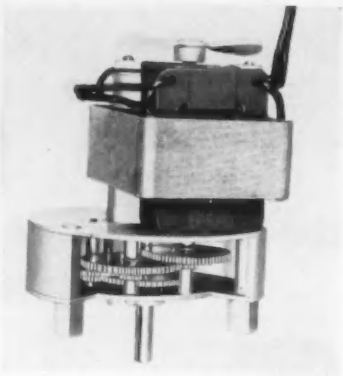
Flush-Mount, Self-Locking Clinch Nuts

These nuts resist temperatures up to 550 F, and they meet AN-N-10 strength requirements. Kaynar Co., Box 2001, Terminal Annex, Los Angeles 54, Calif.

For more information—
Circle 20, inside back cover

Fhp Motor with 2,592,000:1 Gear Ratio

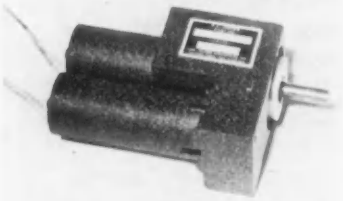
By redesigning the gear box, the selection of final shaft speeds that can be supplied through standard gearing has been extended so that it ranges from 4.5:1 through 2,592,000:1. This makes final shaft speeds available from 600 rpm to 1 rev in 7 days. Shaft



speeds between these limits are available in a virtually continuous range, although not all torques are available in all shaft speeds.

These motors operate on a-c only on all normal voltages and on 25, 50 or 60 cps current. Either synchronous or non-synchronous motors are available. Speed of synchronous motors before reduction is 1800 rpm. Mounting space, $2\frac{1}{8}$ x $2\frac{7}{8}$ x $2\frac{1}{4}$ in., exclusive of shaft. Gear box is $3\frac{1}{4}$ in. dia. Gleason-Avery, Inc., 45 Aurelius St., Auburn, N. Y.

For more information—
Circle 21, inside back cover



Miniature Differential

This is a planetary gear reducer which has been adapted as a mechanical differential device. By mounting the internal gear freely, it may be driven independent of the input shaft and the resultant speed at the output shaft will be the difference between the speed of the input shaft and the speed of the internal gear.

The wide range of planetary reductions available is said to allow flexibility in the output speed range with corresponding torque reductions for higher speeds. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

For more information—
Circle 22, inside back cover

Treated Teflon Yarn

Teflon-coated glass yarn that does not change colors when exposed to high temperatures is now available in white and all colors. It can be furnished semi-cured or sintered. Operating range is −100 F to 500 F. Principal uses for this new yarn are for insulation on aircraft control cable and high temperature lead wire. Chemo Textiles, Inc., W. Warwick, R. I.

For more information—
Circle 23, inside back cover

Time Switches for 2 Sec To 24 hr Control

For control of electrical circuits for periods of 2 sec to 24 hr, these switches provide from 1 to 96 on-off operations every day. They can be used for control of pumps, fans, recorded music, process timing, controlling heating and air conditioning systems, lights. International Register Co., 2624 W. Washington Blvd., Chicago 12, Ill.

For more information—
Circle 24, inside back cover

Motor-Driven Commutation Switch

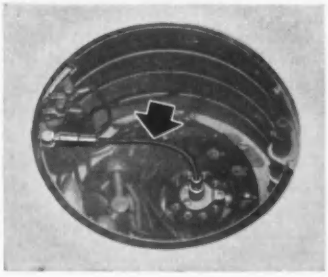
A commutation switch with ceramoplastic commutator plates has two rings of contacts and a maximum of 32 connector leads, brought out to a standard AN connector. Brush size

CONTINUED ON PAGE 238

FLEXIBLE SHAFT IDEAS for ENGINEERS

4 Ways to put a flexible shaft's adaptability to profitable use in machine design

A few of the common design problems you can solve with S.S.WHITE FLEXIBLE SHAFTS

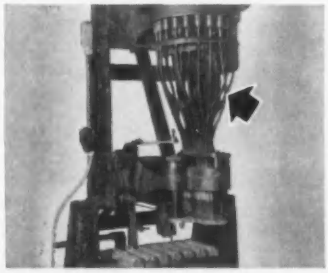


Control of Inaccessible Parts

Even though a rotary switch shown here was located in an inaccessible spot, an S.S.White remote control flexible shaft allows it to be operated from a conveniently positioned control knob on the outside of the equipment. Note that only one shaft is needed to do the job.

Weight Reduction

Electric portable tools can be mighty heavy to handle and difficult to manipulate especially when they need a big motor to drive them. A flexible shaft drive such as the one shown here is the logical solution since it removes the weight of the motor from the operator's hands.



Greater Versatility

The ability of a flexible shaft to be set in a wide range of operating positions is a big advantage in designing equipment like this multiple spindle drill press. The flexible shaft spindles can be set in any desired grouping to meet the requirements of different drilling jobs.

Ideas that may help you design better drives and controls

1. Eliminating Alignment Problems

Where misalignment exists, or where accurate alignment of drive and control elements is likely to be costly and time-consuming, an S.S.White flexible shaft is a "must." The flexible shaft automatically compensates for misalignment, thereby simplifying assembly and eliminating possible operating troubles.

2. Providing Adjustable Drives

Where there is relative movement between driving and driven parts, or where the driven part must be moved or adjusted in operation, an S.S.White power drive flexible shaft is an economical, dependable way to transmit power between the two. The shaft readily adapts itself to any operating position and is capable of giving long trouble-free service.

3. Gaining Extra Design Freedom

Consider the use of S.S.White flexible shafts if you want to gain greater freedom in positioning drive and control elements in their most desirable locations. It will simplify the job of meeting specific operating and service requirements.

4. Satisfying Space Limitations

Flexible shafts are more adaptable, less complicated, less expensive and considerably more compact than systems of bevel gears, straight shafts, belts, pulleys, etc. Their use allows you to develop more efficient, more compact equipment.

FLEXIBLE SHAFT INFORMATION

Bulletin 5601, a helpful informative guide on flexible shaft construction, selection and application, will be sent on request. Write for your copy.

FS-6

FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION, DEPT. D, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

and type, duty cycle and general configuration are standard, but some modification of circuitry is possible. Power supply is 115v, 380 to 520 cps, single-phase, and nominal speed at 400 cps is 5 rps. Noise level is below 50 milliv.

Weight of the complete unit is less than 2 lb. Mycalex Electronics Corp., 125 Clifton Blvd., Clifton, N. J.

For more information—
Circle 25, inside back cover

Explosionproof Magnetic Brakes

This line of direct-acting magnetic disc brakes is for use with all standard electric motors. They have been UL-tested and approved for installation in hazardous locations. Two basic styles are offered.

The 709 series incorporates a thermal release which automatically releases the brake if housing temperature approaches UL-limits. The enclosure will withstand internal explosion, as well as increased temperature within limitations set.

The 707 series brakes are built to withstand an internal explosion, within UL-requirements. Dings Brakes, Inc., 4740 W. Electric Ave., Milwaukee 46, Wis.

For more information—
Circle 26, inside back cover

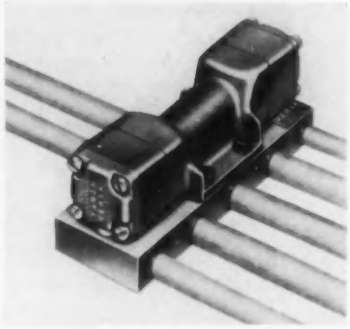
Silicone Rubber Compounds

A series of vinyl silicone rubber compounds which meet aeronautical specifications for high temperature applications are said to have high tear resistance, high elongation, tensile strength of over 800 psi, low compression set, good oil resistance, low moisture absorption, good dry and wet dielectric properties. Union Carbide and Carbon Corp., 30 E. 42 St., New York 17, N. Y.

For more information—
Circle 27, inside back cover

Manifold Mount Control Valves

Available for immediate delivery, this line of control valves is made in two, three, four and five-way types, sizes ⅛ to 1 in. NPT. All piping can be installed, connected to manifold plate, and even purged before installation of the valve itself.



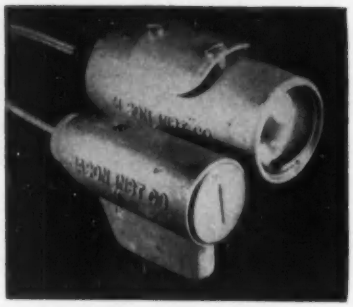
These valves are available with any type of actuating device and for pressures from partial vacuum to 500 psi. Versa Products Co., Inc., 249 Scholes St., Brooklyn, N. Y.

For more information—
Circle 28, inside back cover

Nylon Powder for Pressing, Sintering

A formulation of finely divided nylon powders is reported to be much tougher in the cold pressed and sintered form than the sintered nylons previously available. In addition to gears, the new powder will be applicable for forming bearings, rollers, bushings, cams and similar wear parts. National Polymer Products, Inc., Reading, Pa.

For more information—
Circle 29, inside back cover



Photoelectric Control

Adaptable for counting, sorting, color matching, level detection, edge register, safety, automatic shutoff and alarm, smoke and turbidity control, this unit's "cat's eye" receiver can be rotated to suit conditions. It can control in the horizontal, vertical or any other attitude. This slit also lends itself to readout with a suitable optical shaft position indicator. Mason Instrument Co., 29 Elm Ave., Mt. Vernon, N. Y.

For more information—
Circle 30, inside back cover

Rotary Toggle Switch

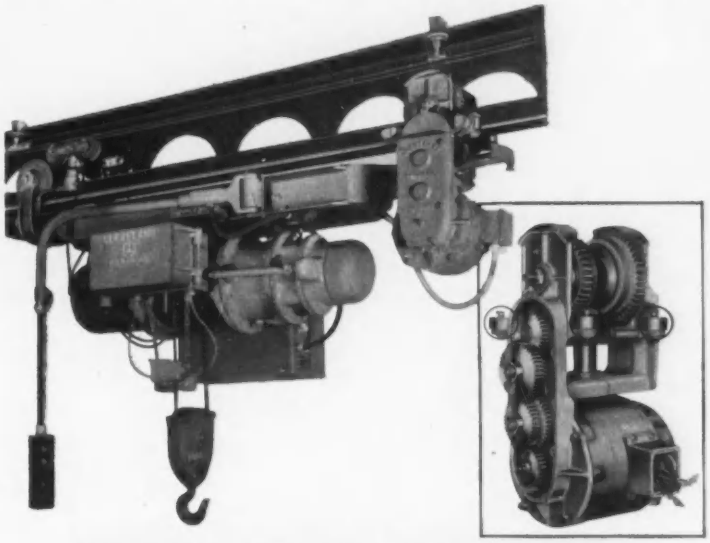
A rotary toggle switch is said to offer a solution to the problem of controlling many circuits with single-motion, mechanical actuation. The small switch can handle a high electrical load, eliminating relays and other electrical devices.

The four-pole, double-throw unit is maintained in all three actuation positions: on-off-on. It has 12 terminals. Other models are available with up to 24 terminals (eight poles).

The switch has an operating force of 9 in-lb max. Electrical rating: continuous capacity of 30 v d-c, 20 amp

CONTINUED ON PAGE 240

BEARING TIPS by McGill



CLEVELAND TRAMRAIL GUIDES MOTOR HEADS ON McGILL CAMROL BEARINGS

Motor-driven electric hoist carriers made by the Cleveland Tramrail Division of The Cleveland Crane & Engineering Company, incorporate McGill CAMROL Cam Follower bearings as side guide rollers for the motor head.

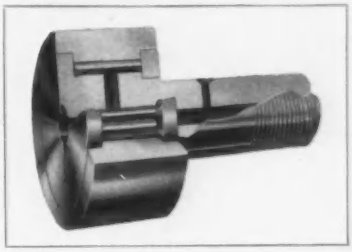
The CF bearings keep the motor head square on the monorail track used in this system and guide the head around curves. Moving on the rails at speeds up to 250 feet per minute, the bearings take the thrust load when entering into a curve.

Replacing spring loaded friction type bolt and roller units, the simplicity of mounting and the friction-free operation of the CAMROL cam followers provide dependable, trouble-free operation of the carrier assembly. Used almost six years, bearing performance has been most satisfactory.

Fact-packed Bearing Catalog

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

CAMROL BEARINGS DIRECT ACCURATE CAM ACTION



Precision built throughout, CAMROL CF Bearings are designed to add the advantages of smooth accurate cam action to rugged shock-absorbing dependability in any type cam follower application. An interchangeable sealed SCF series protects critical installations.

Lodge and Shipley Lathes Support 18′ Propellors on Camrol CYR Bearings

Eighteen foot propeller shafts and other large work are supported and guided accurately on Lodge and Shipley Lathes through use of Camrol CYR Bearings. The Lodge and Shipley Company has standardized on these heavy duty Cam Yoke Roller Bearings for the Roller Jaw Steady Rest on their larger Engine Lathes. Four CYR bearings are mounted in a yoke at the ends of adjustable slides to provide dependable, precision support for a variety of work.

CAMROL CYR Series Adapts To Yoke Mounting

Internal construction of the CYR Series bearing is similar to that of a CF Series bearing with a heavy outer ring selection to withstand shock load. However, the stud is replaced by an inner ring for receiving shaft in a yoke mounting.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

resistive; 5 amp lamp or 12 amp inductive. At 115 v a-c, 20 amp resistive; 4 amp lamp and 15 amp inductive. Micro Switch, Div. Minneapolis-Honeywell Regulator Co., Freeport, Ill.

For more information—
Circle 31, inside back cover

Mounting Stud With Pilot

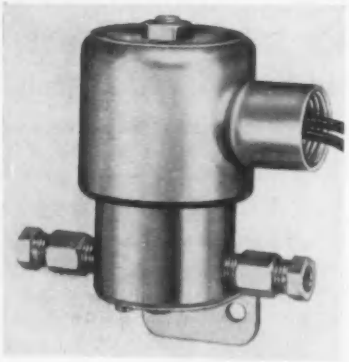
A shoulder on the stud serves as a pilot in locating mounting centers. This eliminates the need for loading fixtures when stud welding. Available either single-ended or double-ended in carbon or stainless steel. Heldor Mfg. Corp., 238 Lewis St., Paterson, N. J.

For more information—
Circle 32, inside back cover

Demountable Plate Cylinders

All surfaces are ground finish. There is practically no movement of parts. They can be mounted or demounted in seconds without heating or fitting required. A spanner wrench is the only tool needed. Paper Machinery and Research Co., Inc., 1014 Oak St., Roselle, N. J.

For more information—
Circle 33, inside back cover



Electro-Pneumatic Valve

An electrically-operated air valve that is said not to talk, hum or chatter is recommended for noiseless control of air conditioning damper motors, as well as for control of pneumatic motors and valves on industrial equipment. When electrically energized, the valve will pass full air at supply pressures up to 25 lb. When not energized, the valve will waste air from its outlet port and close the inlet. A built-in manual adjustment permits the valve to pass air when the coil is not energized.

The 60-cps coil can be supplied for voltages of 115, 208, 230, or 440v. Port connections are $\frac{1}{8}$ in. NPT. The valve is UL-approved. Powers Regulator Co., 3434 Oakton St., Skokie, Ill.

For more information—
Circle 34, inside back cover

Voltage Stabilizer

Output voltage stabilization is automatically obtained by a parallel combination of a fixed capacitance and a magnetic core inductance to provide the variable capacitive current. Voltage stabilization is said to be further improved with a compensating winding to balance the output circuit, with the magnetic circuit so designed as to provide electrical isolation between input and output circuits.

Two styles of stabilizers have been designed. The 15, 25 and 50 va units can be supplied with output voltages of 5.3 or 115 v. Unit measures $9\frac{1}{2}$ x $3\frac{1}{8}$ x $2\frac{3}{8}$ in. Units of 100 to 500 va capacity are available with input of 95 to 130 v and output of 115 v. Acme Electric Corp., Cuba, N. Y.

For more information—
Circle 35, inside back cover

Light-Wall PVC Pipe

A line of light-wall PVC pipe with a uniform pressure rating in all sizes is said to give greater flow capacity than the manufacturer's Schedule 40 and 80 in the same nominal pipe sizes.

There are two basic types in this series. One has high chemical resistance and a maximum working pressure of 150 psi at 75 F. The other has high impact strength and a rating of 125 psi at the same temperature. These two working pressures are constant in all pipe sizes.

This pipe, a rigid unplasticized material, is available in eight sizes ranging from $\frac{1}{2}$ to 4 in. Wall thicknesses range between 0.050 and 0.230 in. All pipe in the series is furnished in standard 10 and 20 ft lengths with plain ends. Carpenter Steel Co., Union, N. J.

For more information—
Circle 36, inside back cover

Copper-Clad Hardenable Steel

This metal combination consists of medium carbon hardenable steel (SAE 1065) clad on one or both sides with oxygen-free, high conductivity copper. The metals are bonded by a solid-phase bonding process without the use of brazing alloys or other intermediate materials. This produces a composite metal having a continuous permanent bond, high conductivity, excellent spring characteristics by heat treatment, resistance to corrosion, ductility for extreme forming, and good operating characteristics at elevated temperature (below tempering temperature).

Typical applications are fuse clips, connectors, springs, and switch parts having high conductivity for rheostats, switches, relays, and thermostats. In non-electric applications such as pen and pencil clips, the copper layers provide an excellent surface for plated finishes. The standard cladding ratio with copper on one side is 80 per cent steel, 20 per cent copper. With copper on either side the standard is 10-80-10. Other single and double clad ratios can be produced. General Plate Div., Metals & Controls Corp., 43 Forest St., Attleboro, Mass.

For more information—
Circle 37, inside back cover

Sealed Bearing Caster

This caster has a lip-type neoprene seal which seals both swivel races and wheel bearings against dirt, grit, water, acids and other contaminants. It is

CONTINUED ON PAGE 242

Is this Garter Spring necessary on your Oil Seal application?

The answer lies in an individual *evaluation of your application.* Garter springs, where not required, can take a "free ride" at your expense. The mechanical action created by garter springs can result in excessive torque and friction . . . can often shorten seal life . . . can actually cause shaft wear.

IPC seals are designed, compounded and bonded to provide inherent resistance to operational stress, *often without the added cost of mechanical "pinch".*

If excessive eccentricity, temperature range or other conditions do warrant the use of mechanical "pinch", IPC engineers will design your oil seal to combine custom compounding with minimum spring "pinch" consistent with good performance.

Before you buy, ask for IPC's recommendation.

INTERNATIONAL PACKINGS CORPORATION

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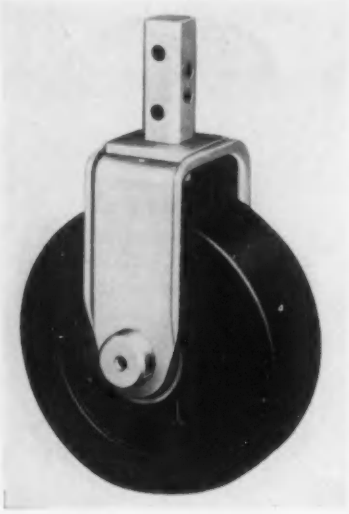
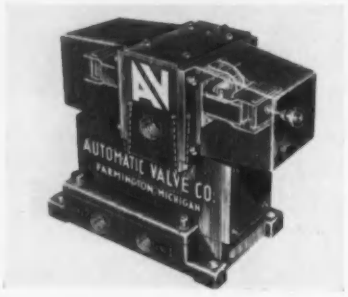
1. Bonded Washer Seal Double Lip Wiper
2. Bonded Case Seal Double Lip Wiper
3. Bonded Washer Seal Straight Lip
4. Bonded Washer Seal Limited Contact Lip
5. Bonded Washer Seal Straight Lip With Garter Spring
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
7. Bonded Case Seal Straight Lip
8. Bonded Case Seal Limited Contact Lip
9. Bonded Case Seal Straight Lip With Garter Spring
10. Bonded Case Seal Limited Contact Lip With Garter Spring
11. Bonded Case Seal Straight Lip Thin Rind Type
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
13. Rubber Covered Bonded Case Seal Straight Lip
14. Rubber Covered Bonded Case Seal Limited Contact Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

P6



available in industrial and institutional casters with steel, plastic, V-groove and molded rubber wheels. Colson Corp., Elyria, Ohio.

For more information—
Circle 38, inside back cover

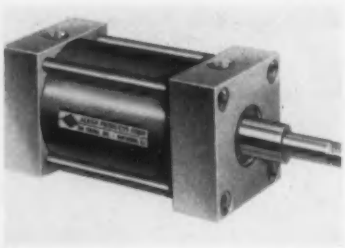


Double Solenoid Air Valve

A four-way, four-port and four-way, five-port, pilot-operated, double solenoid air valve is available made to JIC standards. This valve has a spool-type pilot. By momentarily energizing one solenoid, the spool is moved and the main valve shifted. The main valve stays in this position until the other solenoid is momentarily energized and it then shifts back to the original position.

The valve is made in $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{8}$ in. Automatic Valve Co., 37415 Grand River Ave., Farmington, Wash.

For more information—
Circle 39, inside back cover



Cylinders with Non-Rotating Rods

A series of double-acting cylinders with elliptical non-rotating piston rod is now available in $1\frac{3}{4}$ and $2\frac{1}{2}$ in. bores, for immediate delivery from stock. An elliptical bushing which is adjustable to permit compliance with different rod fit requirements, as well as to compensate for eventual wear, is provided.

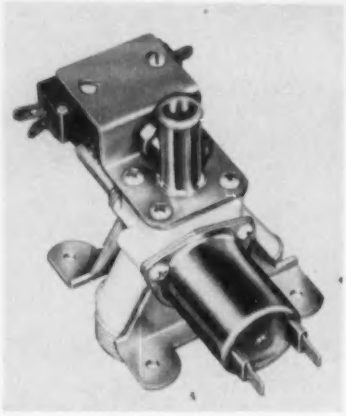
The cylinder is rated 250 psi air, 500 psi water or oil. It is available with all standard interchangeable mounts, in all standard strokes, cushioned or non-cushioned. Alkon Products Corp., 200 Central Ave., Hawthorne, N. J.

For more information—
Circle 40, inside back cover

Sequence Timer-Recorder

Designed for split-second monitoring of multi-operational automatic machinery, up to fourteen operating sequences can be simultaneously timed to within 1/100 sec and recorded on a strip chart for visual reference. About the size of a portable radio, the unit can be plugged into an electrical control circuit without shutting the machine down, and no other external power supply is required. Autometrology Div., Sheffield Corp., Dayton 1, Ohio.

For more information—
Circle 41, inside back cover



Solenoid-Controlled Mixing Valve

A three-temperature thermostatic water mixing valve recently developed uses an externally mounted switch that alternately opens and closes solenoids so that the flow of water or other fluid supplied is of uniform temperature. Detroit Controls Corp., 5900 Trumbull Ave., Detroit 8, Mich.

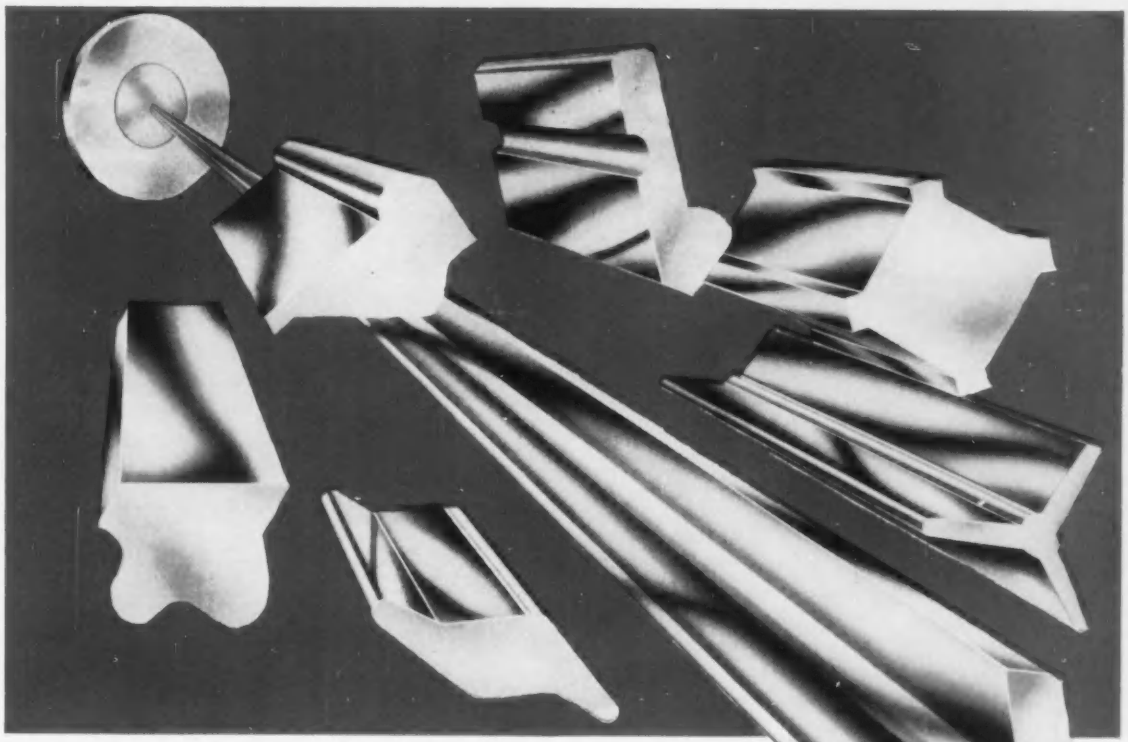
For more information—
Circle 42, inside back cover

Differential Speed Reducer Pulley

This is a V-belt pulley having an internal gear reduction ranging up to 8000:1, plus a torque disc designed for driving through a separate control motor to provide differential action. In the standard reduction pulley, this torque disc, to which is attached a held gear, is in a fixed position, and as the pulley revolves around this gear, reduction is obtained through the internal planetary gear train.

Driving this torque disc and held gear by means of an attached sprocket, provides differential action at any desired controlled speed. It can be ar-

CONTINUED ON PAGE 244



J&L custom-made hot extruded cold drawn sections... boost production, cut over-all costs

Progressive industry is today utilizing J&L's Custom-Made, Hot Extruded Cold Drawn Steel Sections to:

1. **Eliminate time and costs** in machining and finishing operations
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The mechanical properties of J&L Extruded Sections are equal to or superior to those obtainable from equivalent grades conventionally cold drawn. Cold drawn tolerances are accurately maintained. The excellent surfaces of these Extruded Sections require little — if any — finishing operations.

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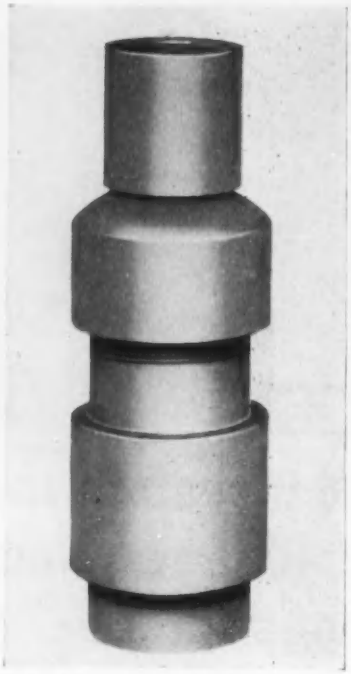
ranged for either chain or V-belt drive, and can be driven in either direction. Shaft mounted, it requires no mounting brackets or bearings. Can be adapted to either reduce or increase speeds. Hart Reduction Pulley Co., 426 W. Main St., Waukesha, Wis.

For more information—
Circle 43, inside back cover



PVC Expansion Joint

This slip-type pipe expansion joint of unplasticized PVC is made in 1, 2 and 3 in. sizes, and may be used with piping of smaller diameters by employing reducing bushings. All sizes allow an expansion of 3¾ in.

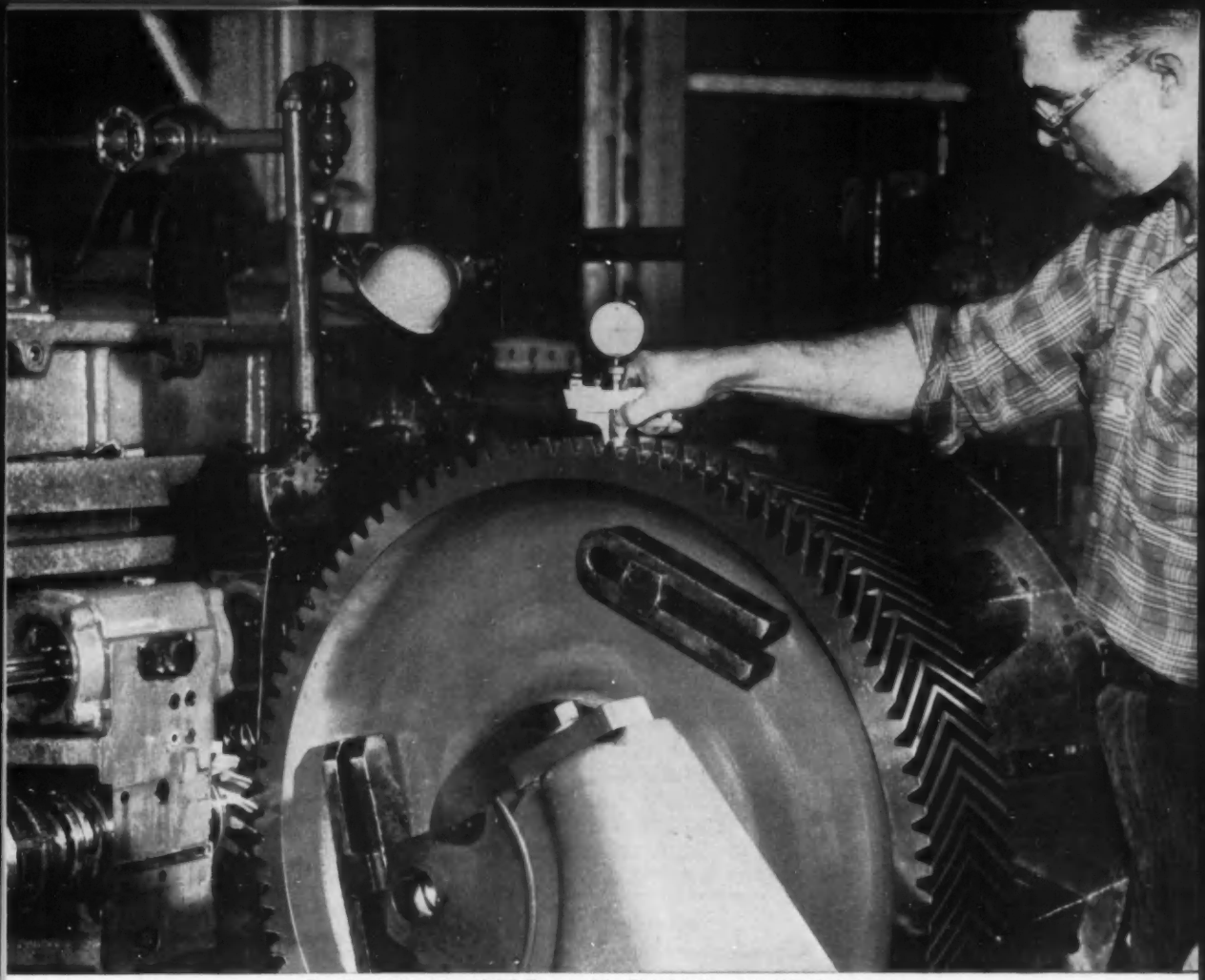
The joint has been tested at pressures up to 325 psi, and temperatures up to 140 F. Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.

For more information—
Circle 44, inside back cover

Constant Level Oiler

These units can be used on bearings, gear boxes, pump housings, moistening pads. When the oil level in the bearing recedes because of oil consumption the liquid seal on the spout

(Continued on page 246)



Checking teeth pitch on 32" O.D. gear at the Philadelphia plant of Link-Belt Company.

speed up machining, extend cutter life with Standard Steel forged gear blanks

By switching to Standard Steel forged blanks for the helical and herringbone gears used in their enclosed drive units, the Philadelphia plant of Link-Belt Company has speeded up machining time and lengthened cutter life substantially. That's because:

- Dimensional tolerances are closer, so all gear blanks of the same size can be machined on a single setup.
- Standard Steel forged blanks have no blow holes, porosity or non-metallic inclusions, so finish turning, facing, boring and hobbing can be done faster.
- High speed cutters last much longer because these forgings have a more uniform internal structure.

Link-Belt's experience in reducing costs is typical of hundreds of other manufacturers. When you specify Standard Steel forgings, you get a product that is quality-controlled from start to finish. We produce our own acid open hearth steel, heat treating and tempering it carefully. Finished forgings are carefully inspected and checked to assure meeting customer specifications.

In addition to gear blanks, Standard Steel can furnish you with rings, flanges, shafts, wheels and special shapes—and furnish them *fast*. Next time you need forgings, get our quotation first. For a copy of our new bulletin, write us at Dept. 8935, Standard Steel Works Division, BLH Corporation, Burnham, Penna.

BALDWIN · BLH · LIMA-HAMILTON

STANDARD STEEL WORKS DIVISION

BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Lima Electronics & Instrumentation • Hamilton • Pelton • Loewy-Hydropress • Madsen

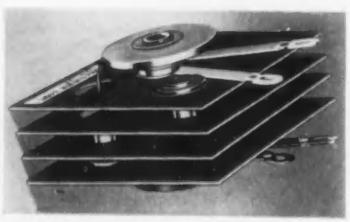
inside the oiler is temporarily broken. This allows air from the air intake to enter the oiler reservoir, releasing oil until a seal and the proper level is again restored. Transparent reservoirs permit a visual check of the oil supply at all times and since the oil in the reservoir will assume the same color as that of the bearing housing it affords also a visual check on the condition of the oil. Oil-Rite Corp., 2382 Waldo Blvd., Manitowoc, Wis.

For more information—
Circle 45, inside back cover

Thermal Relief Valve

A series of two relief valves, which may function as a thermal relief or main relief valve, cover a range of 1000 to 3850 psi, with flows of 15 cc per min to 2000 gpm. Both models comply with AN6245, weigh 2¼ oz and are available for $\frac{7}{16}$-20, NF-3 threads or ¼-18 NPT. Electrol Inc., Kingston, N. Y.

For more information—
Circle 46, inside back cover



Silicon Rectifier Stacks

The stacks are designed for power applications where high ambient temperature, reliability, high efficiency and miniaturization are of prime importance. These silicon rectifiers are now available in all circuit types, with

(Continued on page 250)

NEW

CALIDYNE
model 174 SHAKER
1500 lbs. force output

a basic shaker for 6 different CALIDYNE Vibration Test Systems

SYSTEM NUMBER	1 174/203	2 174/184	3 174/80	4 174/186	5 174/186	6 174/80
Type	Sinusoidal	Sinusoidal	Sinusoidal*	Sinusoidal*	Random or Sinusoidal	Random or Sinusoidal
Power Supply	Electronic	Rotary	Electronic	Electronic	Electronic	Electronic
Force Output	1250 lbs.	1500 lbs.	1500 lbs.	1500 lbs.	1500 lbs.	1500 lbs.
Frequency Range	5-3500 cps.	5-2000 cps.	5-3500 cps.	5-3500 cps.	5-3500 cps.	5-3500 cps
Max. Load 10 g.	105 lbs.	130 lbs.	130 lbs.	130 lbs.	130 lbs.	130 lbs.
Max. Load 20 g.	42.5 lbs.	55 lbs.	55 lbs.	55 lbs.	55 lbs.	55 lbs.

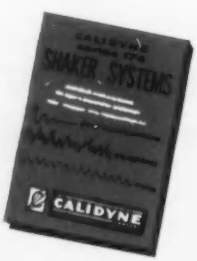
*Also adaptable for Random Vibration Testing.

CALIDYNE'S Model 174 Shaker featuring high frequency operation and low input requirements has been so designed that it can be utilized in any one of six CALIDYNE Vibration Test Systems.

The versatility of the Model 174 Shaker extends the range of vibration testing for which this shaker can be used. It further advances CALIDYNE Systems of vibration control, enabling equipment manufacturers to: create vibratory forces over a wide range, measure them, use them for testing and measuring the test results.

Typical vibration testing applications of these Model 174 CALIDYNE Shakers include:

1. **Brute force** shaking at frequencies simulating the worst conditions of ultimate operation.
2. **Structural response** to determine mode shape, frequency and damping characteristics.
3. **Fatigue testing** for high stress providing deflections many times greater than normal usage.
4. **Random** vibration testing for more exact simulation of true environment.



Complete performance data on each of these 6 CALIDYNE Series 174 Shaker Systems are contained in New Bulletin 17400. For engineering counsel in applying the destructive force of vibration to your own research and testing problems, call us here at CALIDYNE.

THE CALIDYNE COMPANY
120 CROSS STREET, WINCHESTER, MASSACHUSETTS

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Syracuse, N. Y. (Syracuse 3-7870)
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G. Curtis Engel & Associates
Ridgewood, N. J. (Gilbert 4-0878)
Syosset, L. I., N. Y. (Walnut 1-5095)
Philadelphia, Pa. (Chestnut Hill 8-0892)
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Denver, Colorado (Acoma 2-9276)
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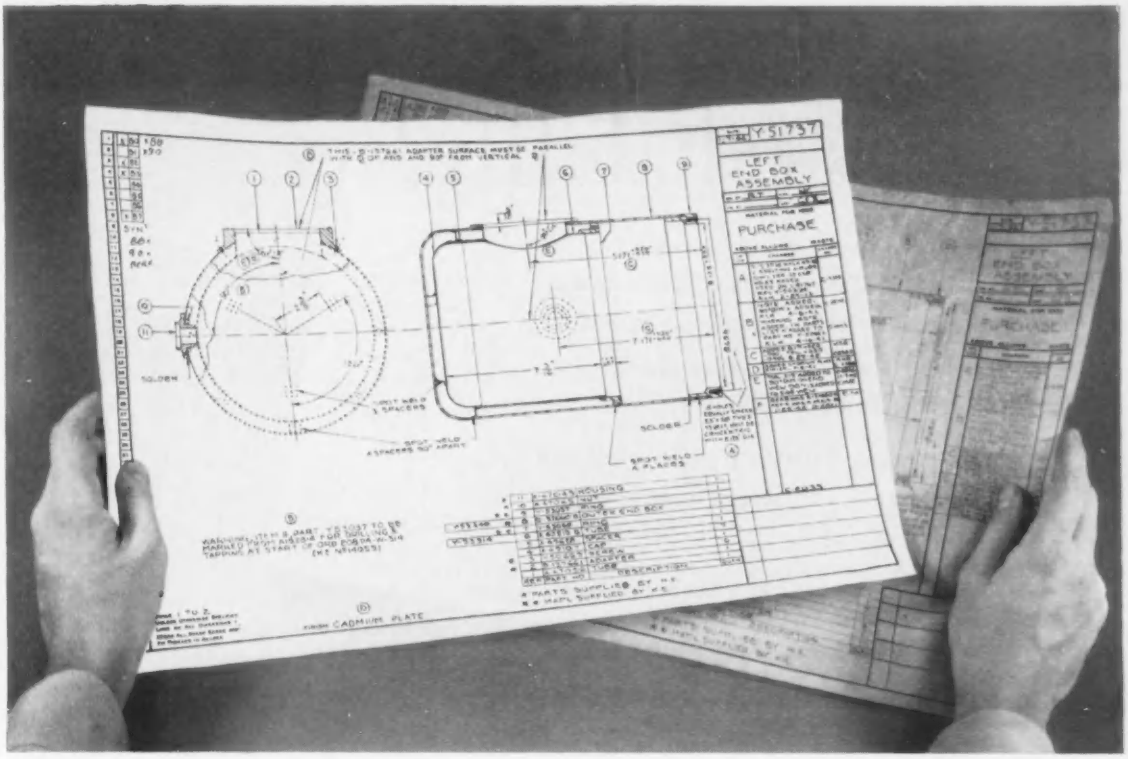

This Autopositive Paper intermediate was made from an old, "yellowed" drawing

To restore old drawings *without retracing a line*

Take one of your old pencil drawings that is so worn and yellowed it will no longer produce acceptable prints.

Reproduce it on Kodagraph Autopositive Paper, and you'll get a positive reproduction directly.

Now run prints from this photographic intermediate. You won't believe your eyes—the lines are crisp, legible... the background wonderfully cleaned up. *These* are prints you can use!

With Kodagraph Autopositive Paper around, it just doesn't pay to waste hours retracing "unprintable" originals, as thousands of drafting rooms have discovered.

Learn all the ways you can save with Kodagraph Reproduction Materials, which you, or your local blueprinter can process quickly, at low cost.

EASTMAN KODAK COMPANY
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New booklet is jam-packed with valuable tips on saving drafting time, protecting drawings, getting better prints.

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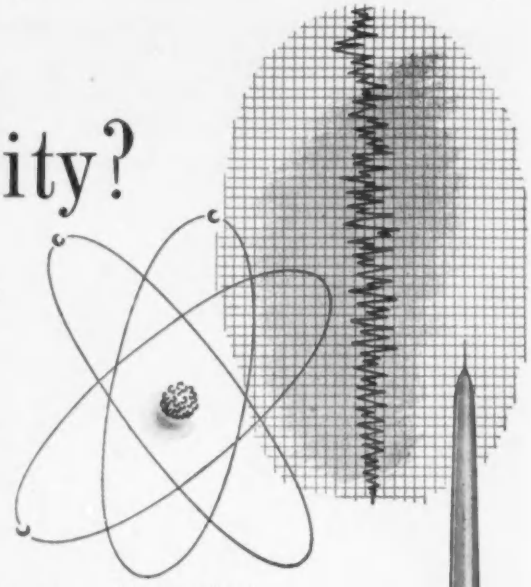
FIRST OF A SERIES

What is reliability?



Industry in the United States is becoming more and more complex... we're getting automated ... computers are computing... the missiles are flying... the digits are digitizing...

And the word "Reliability" takes a new and different meaning... what does it mean to you?

It's time to stop and take a look! Ask three of your friends how they define "reliability." You'll be surprised at the different answers you receive. And when you quiz them further on how much reliability is needed in a particular product... how they would control the design and manufacture of that product to obtain the amount of reliability they want... you'll be even more surprised by the variety of the answers.

So... let's define reliability. Let's start off with a definition that is gaining the most acceptance in the technical field...

The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time.

Looks simple enough!

But what hazards it presents! The first important challenge is that word "probability"... it takes you seriously into the field of data collection and statistical analysis. Then you check into the phrase "do what it is supposed to do"... someone must define these objectives. And, look at the "operating conditions"... pause briefly and reflect on the many different conditions under which products operate. And, finally, note the phrase "for a specified operating time"... does one normally, consciously, define reliability in terms of time?

These considerations pose problems for all of us... the manufacturers of components, those who assemble components into other products, systems personnel, designers, industrial engineers, production workers, purchasing agents, quality control... *and users!*

Let's look at the word "probability."

Picture a chain, with its successive links. Many of today's systems, simple or complex, comprise such a chain of components. However, as we all know, that chain will be only as reliable as its weakest link. And, statistically, the over-all reliability of the chain or system is the mathematical product of the reliabilities of the individual links expressed as...

Over-all Reliability, $R_0 = r_1 \times r_2 \times r_3 \ldots r_n$

As an example, assume a product has a chain of 100 components in which each component has a reliability of 99 per cent... which assumes that only one out of a hundred units of each component will fail. These are relatively high standards established by past practices. But what happens? Multiplying .99 by itself one hundred times ($.99^{100}$), note that our chain of components will have a reliability of only 36.5 per cent! Two out of three of our chains would probably fail!

As another example, let's look at contacts in a multi-contact electric connector. If, for instance, we are to assemble connectors containing 25 similar contacts from a 1% defective contact population, we can expect 22% of the connector assemblies to contain one or more defective contacts! See how the multiplication of probabilities presents a major challenge to both designer and manufacturer?

But all is not lost! There is another side of the picture. With proper care, analysis, and control, our organization at Cannon has actually achieved, in special "missile quality" contacts, a known level of only 2.85 x 10^{-3}% defective... or one defective part in 35,000! Naturally, we don't achieve

that with all our contacts . . . but we do try to design and manufacture the utmost in reliability required for specific applications.

However, to return to your problems and to go a step further in demonstrating "probability" of uncontrolled contacts . . . and the challenges it poses to you and to us . . . consider the case where we have three groups of contacts, each group with contacts of different sizes. Let us assume, also, that each group has different percentage defective populations and that the three groups are assembled in a 90-contact connector as follows:

50 No. 16 contacts with a population reliability of .59;
25 No. 12 contacts, reliability .60; and 15 No. 8 contacts, reliability .64.

Then . . .

$$R_c \text{ (90 contact connector)} = r_{\#16} \times r_{\#12} \times r_{\#8}$$

or,

$$R_c \text{ (90 contact connector)} = (.59)\ (.60)\ (.64) = .23$$

It is apparent from the above that connector contact populations must be maintained at extremely low values of percentage defective. This is of extremely vital importance if we are to produce connector assemblies which will perform satisfactorily in systems utilizing series circuitry, where the failure of one contact pair can cause failure of the entire system.

We have been talking only about *a contact* . . . just one of the many different materials and parts (such as contact pins, insulators, shells, and couplings) going into the more than 20,000 different connector and electrical items we manufacture. Think of the "product of reliabilities" rule in systems comprised of tens, hundreds, or thousands of electrical components connected by connectors such as ours. Regardless of whether they design, manufacture, sell, or use washing machines or guided missiles, everyone faces the same problem. That's why we're taking some of your valuable time to present the important subject of reliability here.

*

All of us, when we specify materials, parts or components must constantly keep in mind the (a) "probabilities," (b) what the part is supposed to do, (c) the operating conditions, and (d) the time it must operate satisfactorily. Let's see what we can do to increase reliability in relation to these four factors:

(a) Probabilities. To increase the reliability of any component, and thereby the system as a whole, it is necessary to think in terms of statistical distribution of important physical properties. From field reports of failure and laboratory test results, we must first isolate those properties which most frequently cause trouble. It is then necessary to determine whether poor performance is due to lack of process control to keep the product within specified tolerance limits, whether the dollar sign has entered into the picture too far—cutting reliability down for the sake of a few cents here or there—or whether the design itself is inadequate for an end-use application. In any case, the use of the statistical approach to problem solution offers a positive method of obtaining known levels of reliability.

(b) Definition of Function of Product. Each component and each system . . . both civilian and military . . . in each different field of endeavor, in each product produced, has different functions. None of us should "overbuild" . . . nor should we "under-build." We should look at our specifications closely.

(c) Operating Conditions. Temperature and pressure, humidity, corrosive atmospheres, stray electric and magnetic fields, low and high frequency noise, shock and vibration . . . all must be considered plus conditions prior to product use.

(d) Operating Time. This varies both for different products and different fields of application. Have you set reasonable lengths of operating time for your product or system, from the viewpoints of both usage and economics?

*

We at Cannon Electric are proud of our historical emphasis on quality and reliability. Since our inception in 1915 we have consistently adhered to a design philosophy embracing the highest quality and reliability in each Cannon Plug for the specific application for which it is to be used. *If we cannot design to that principle, we don't make it!* In manufacture, we are proud of our know-how in depth, proud of our fine quality control systems, proud of our personnel, and proud of our reliability control group. The "Cannon Credo" . . . part and parcel of the everyday life of each Cannon employee . . . is posted in all offices and all departments of all eight Cannon plants around the world. Three of its sections read as follows:

To develop an organization of exceptional people possessed of respect for the dignity of the individual and imbued with the spirit of the team.

To provide a facility with which we can produce to our utmost in an efficient and pleasant environment.

To develop and produce products of such quality, and render such service, that we may always be proud of our efforts.

*

Whenever *you* have an electric connector reliability problem . . . in design, engineering, production or prototype phases . . . we would welcome the opportunity of discussing it with you.

Cordially,

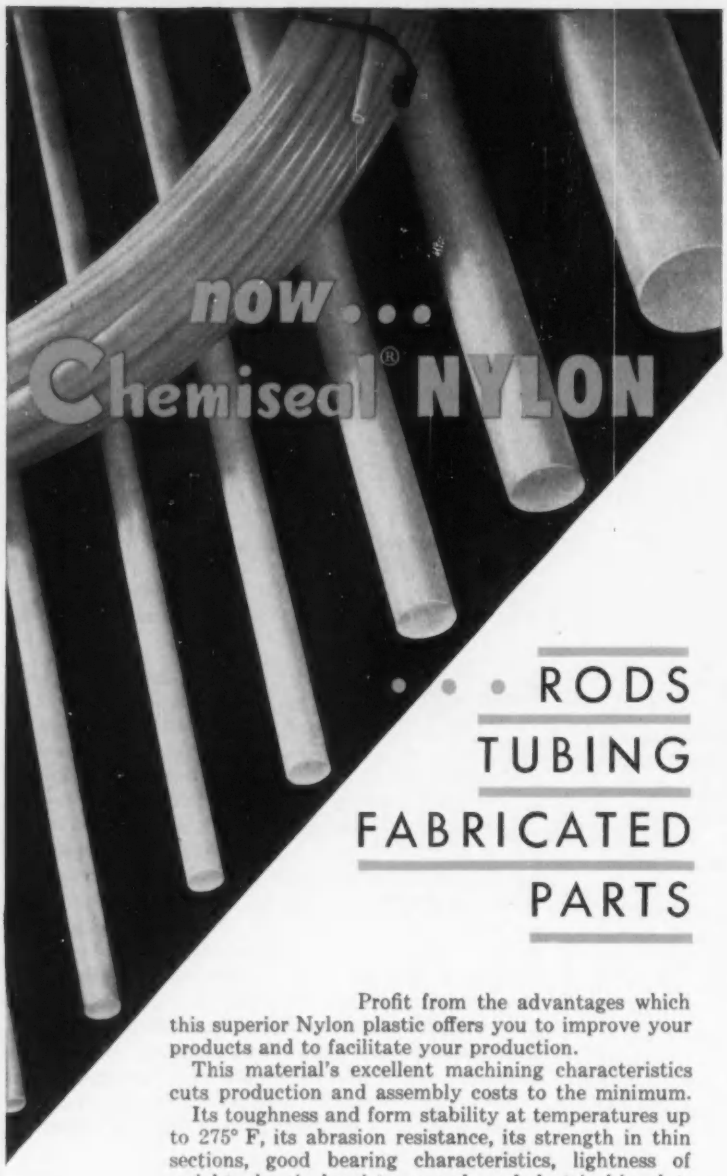
Robert J. Cannon *President*

CANNON ELECTRIC COMPANY
3208 Humboldt St., Los Angeles 31, California

Please Refer to Dept. 106

CANNON PLUGS

Eight plants around the seven seas!



RODS
TUBING
FABRICATED
PARTS

Profit from the advantages which this superior Nylon plastic offers you to improve your products and to facilitate your production.

This material's excellent machining characteristics cuts production and assembly costs to the minimum.

Its toughness and form stability at temperatures up to 275° F, its abrasion resistance, its strength in thin sections, good bearing characteristics, lightness of weight, chemical resistance and good electrical insulating properties recommend it for a wide variety of mechanical and electro-mechanical applications.

Specify Chemiseal Nylon Rod and Chemiseal Nylon Tubing (du Pont ZYTEL) now fabricated by United States Gasket Company "Quality Control" methods.

Available in all standard rod sizes from ⅛" to 2" inc. Tubing is supplied in sizes up to ½" dia. OD in various wall thicknesses. Precision machined parts to your specifications.

Write for further information.

U G S BELMONT

UNITED STATES GASKET CO.

CAMDEN 1, NEW JERSEY

rms inverse voltage ratings of 70, 105, 140, 210, 280, 350 and 420 v, and d-c output currents up to 4.5 amp at 75 C ambient temperature. It is possible to arrange the stacks in series and parallel to increase voltage or current ratings. International Rectifier Corp., El Segundo, Calif.

For more information—
Circle 47, inside back cover

Needle and Globe Valves Of PVC

These valves are designed to operate up to 170 psi, continuous duty, and in lower pressure systems may be used safely at temperatures up to 170 F, or higher for intermittent duty. The valves are available in ⅛ and ¼ in. pipe sizes and ⅛, ¼ and ⅜ in. OD male tube connections.

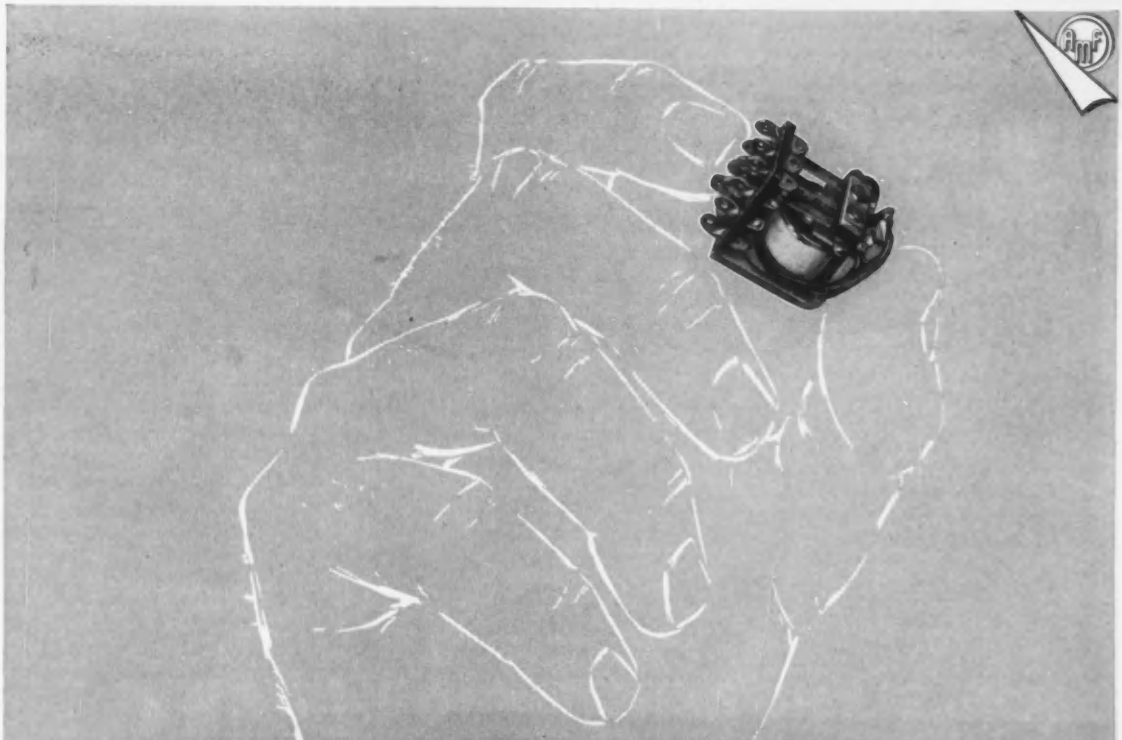
Desirable arrangements in both globe and needle types include panel, wall, angle, multiple and shock mounting, quick disconnect, adjustable, insulated bracket and swing mounts, and direct attachments to other units. Chemtrol Corp., 11008 Santa Fe Avenue, Lynwood, Calif.

For more information—
Circle 48, inside back cover

Swivel Coupling

A four-bolt, split-flange, pressed on coupling is available with 360 deg swiveling action. The new fitting is

(Continued on page 253)



NEW! SUB-MINIATURE 3-POLE P & B RELAY FOR MULTIPLE SWITCHING

KM SERIES
ENGINEERING DATA

CONTACTS:
Max. 3PDT. 3/32" Dia. Silver
2 amps, 115V 60 cy. resistive

VOLTAGE RANGE:
Up to 48V DC nominal

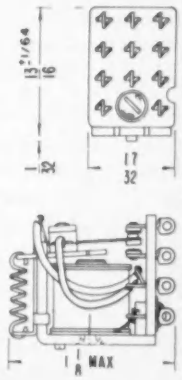
COIL RESISTANCE:
Up to 6700 ohms

COIL POWER REQUIREMENT:
1 watt

TEMPERATURE RANGE:
−45° C to + 55° C

PULL-IN:
75% of nominal voltage

TERMINALS:
Solder lugs



This new P&B KM series was engineered to meet the pressing demand for miniaturization and multiplicity of action within a single relay. Application possibilities cover a wide field of diverse products, such as:

SMALL BUSINESS MACHINES
ALARM SYSTEMS — INTERCOM SYSTEMS
AUTOMATIC TOYS — REMOTE CONTROLS

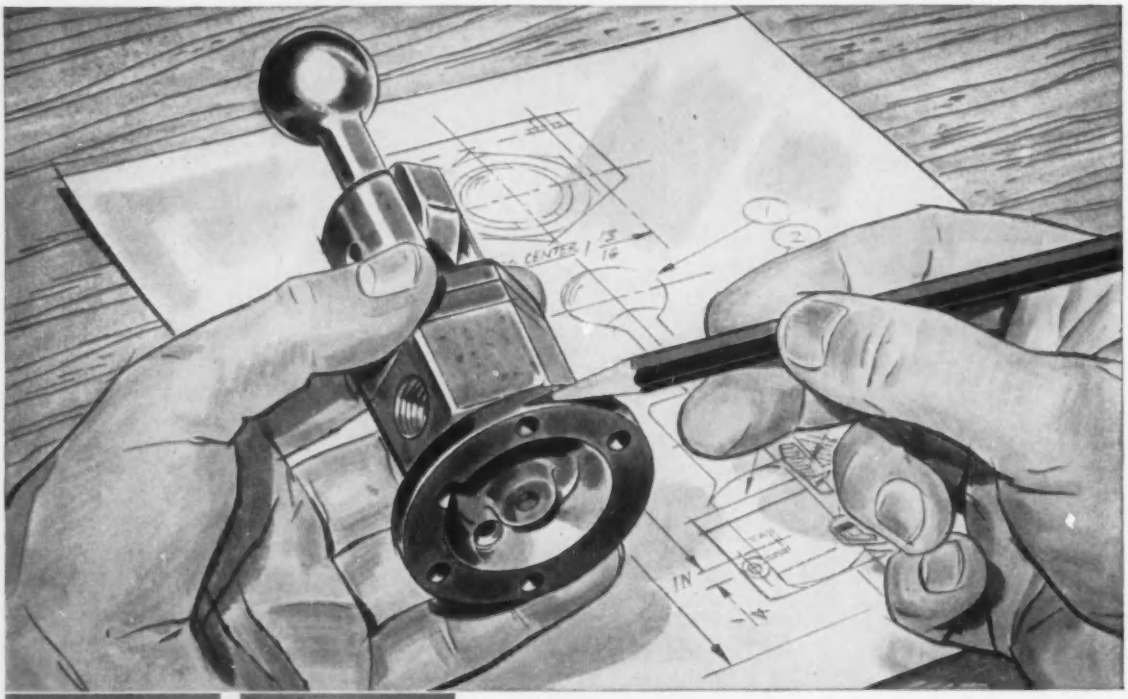
Here is only one of the great family of P&B relays . . . one of more than 20,000 design variations. Custom modification of relays, too, is a P&B specialty. Thus you have *one dependable source* for ALL your relay needs!

KM RELAY ABOVE SHOWN ACTUAL SIZE

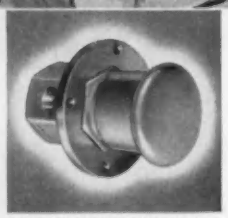
P&B STANDARD RELAYS ARE AVAILABLE AT MORE THAN 500 DISTRIBUTORS IN ALL PRINCIPAL CITIES

Potter & Brumfield inc.
PRINCETON, INDIANA
SUBSIDIARY OF AMERICAN MACHINE AND FOUNDRY COMPANY

Simplified design . . . versatile mountings . . . distinguish new **MAC** pilot valves



NEW FOOT VALVE — small and compact, has adequate treadle area. Anchors easily.



NEW PALM-BUTTON VALVE —suitable for panel mounting. Returns to normal position.

NEW SOLENOID VALVE — instant action. Protective cover is easy to remove.

NEW CAM VALVE — built-in overtravel prevents damage when operated by cam series.

NEW HAND VALVE—available in either locking or non-locking type. May be used singly or in series for working pressures up to 150 P.S.I.

Design makes the difference in these pilot valves. And it's easy to spot. MAC's new pilot series is trim and compact. The valves are lightweight, and smaller . . . have fewer parts. By simplifying design, MAC engineers virtually eliminated maintenance . . . built in dependability for millions of cycles.

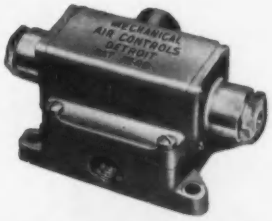
You'll find MAC pilot valves tops for convenience, too. A variety of mountings mean they can be installed almost anywhere—close to hand or foot, or overhead and out of the way. And, of course, this new pilot series reflects the precision and quality workmanship that mark *all* MAC valves.

So, look to MAC for *all* your air valve needs—solenoid, pilot operated *and* pilot . . . any size or type. We've got the answer —*and exactly the right valve*—for any air control problem. Write us or contact a representative listed at the side.

MECHANICAL AIR CONTROLS, INC.

Office and Factory—10030 Capital, Oak Park, Detroit 37, Michigan

MAC



PHONE YOUR NEARBY "MAC" REPRESENTATIVE FOR DATA AND DELIVERY

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FORT WAYNE 3—Neff Engineering Co., P.O. Box 2001, Station A, 2339 Crescent Ave., EAstbrook 7391
INDIANAPOLIS 20—Neff Engineering Co., P.O. Box 7361, 42nd St. Station, BRoadway 2330
SOUTH BEND—Dick Futter, 103 South Varsity Dr., CEntral 2-3800

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Western Michigan—Everett Adams, 17212 Sharon Road, Chesaning, Michigan; Chesaning 383-J-1

MINNESOTA
MINNEAPOLIS 4—Air Engineering & Supply Co., 2445 Nicollet Ave., FEderal 9-5579
ST. PAUL 14—W. H. Schulz Co., 2438 Franklin Ave., MIdway 4-2791

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TEXAS
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SEATTLE—The Rucker Co., 1000 4th Ave., South, MAin 2783

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MECHANICAL AIR CONTROLS, INC.
DETROIT 37, MICHIGAN

MAC

available in all sizes from ¼ through 1½ in., and in all standard bends from zero to 90 deg. Anchor Coupling Co. Inc., 342 N. 4 St., Libertyville, Ill.

For more information—
Circle 49, inside back cover

Trimming Potentiometer

A miniature trimming potentiometer has a body and cover made of aluminum. These units are adjustable throughout 32 turns by a screwdriver in a slotted shaft. Torque is constant throughout the adjustable range.

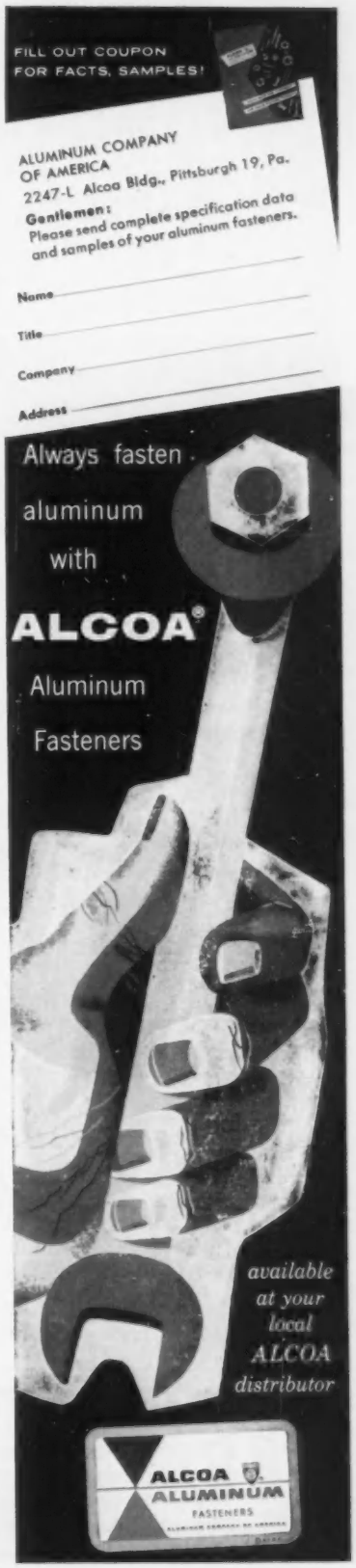
Case dimensions are 1¼ x ½ x ⅜ in. wide. Weight: ¼ oz. Resistances range from 100 to 50,000 ohm in one case size. Resolution, depending on resistance: 0.2 to 2 per cent. Linearity is 1 per cent. Temperature range: −55 C to 125 C. Aero Electronics, 2311 W. Burbank Blvd., Burbank, Calif.

For more information—
Circle 50, inside back cover

Switch Assemblies

This combination of a micro-switch unit and cam assembly is a single-throw, double-pole limit switch, rated

(Continued on page 254)



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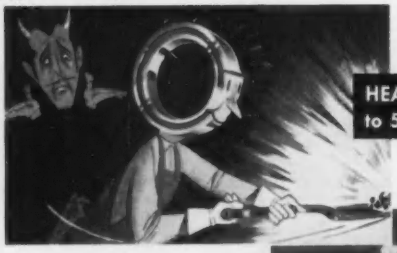
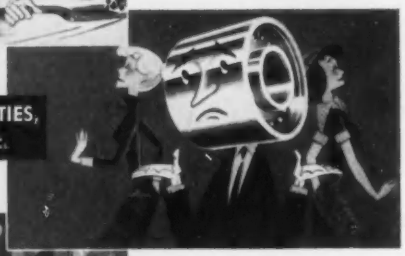
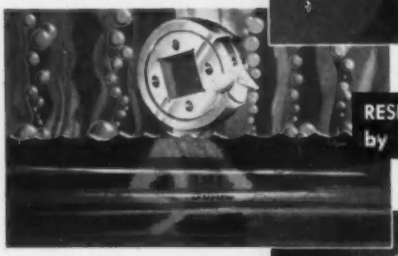


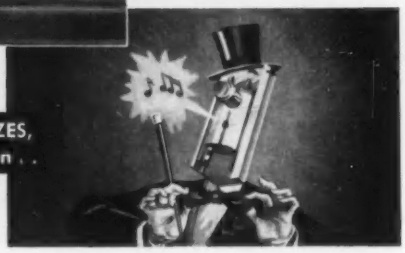
HEAT RESISTANCE — to 500° – 1000° – 1500° F



NON-MAGNETIC PROPERTIES, electrical conductance, etc.



RESISTANCE TO CORROSION by Acids – Caustics – Salts



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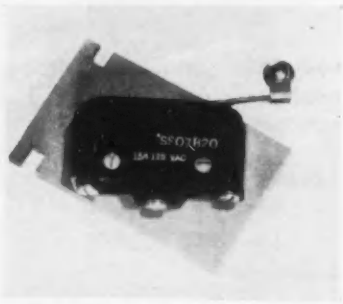

at 10 amp for 24 to 30 v d-c and 0.6 amp at 110 to 125 v a-c. It is mounted on a component hanger. Switch terminals permit its use as either a normally closed or a normally open unit.

The cam assembly consists of a pair of cams which are used in conjunction with the switching unit to open or close a circuit at a specific shaft position. A pulse disc can also be used in conjunction with the switch to open or close a circuit at a number of specific shaft positions. The pulse disc is provided with 36 tabs and their hardware. Servo Corp., of America, 20-20 Jericho Tpk., New Hyde Park, N. Y.

For more information—
Circle 51, inside back cover

Explosionproof Pressure Control

The enclosure for this control provides for use in Class I, Groups C and D locations. It is an uncalibrated unit, and pressure settings are made by means of an internal adjusting nut. Models are available with a variety of adjustable ranges, between the limits of 0 and 500 psi, and maximum pressures of up to 600 psi. On-off differentials between the limits of 2 and 30 psi are obtainable.

Basic components include a pressure assembly and a snap-acting switch that is operated by the pressure assembly. The assembly consists of a bellows, load spring, spring tension (or setting) adjustment, and plunger. The load spring creates a force in opposition to the movement of the bellows. As pressure is applied to the bellows, the bellows expands against the force of the load spring and causes the plunger to move toward the switch. When the pressure reaches a pre-set

(Continued on page 258)

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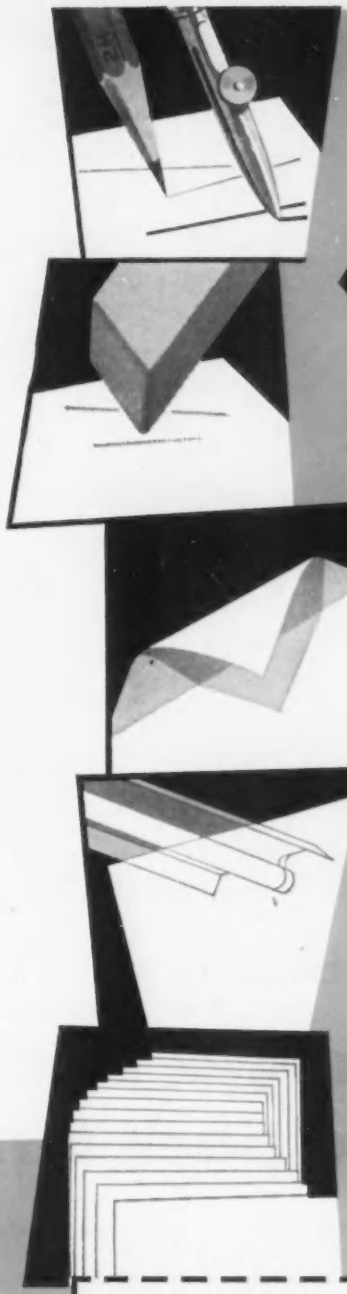

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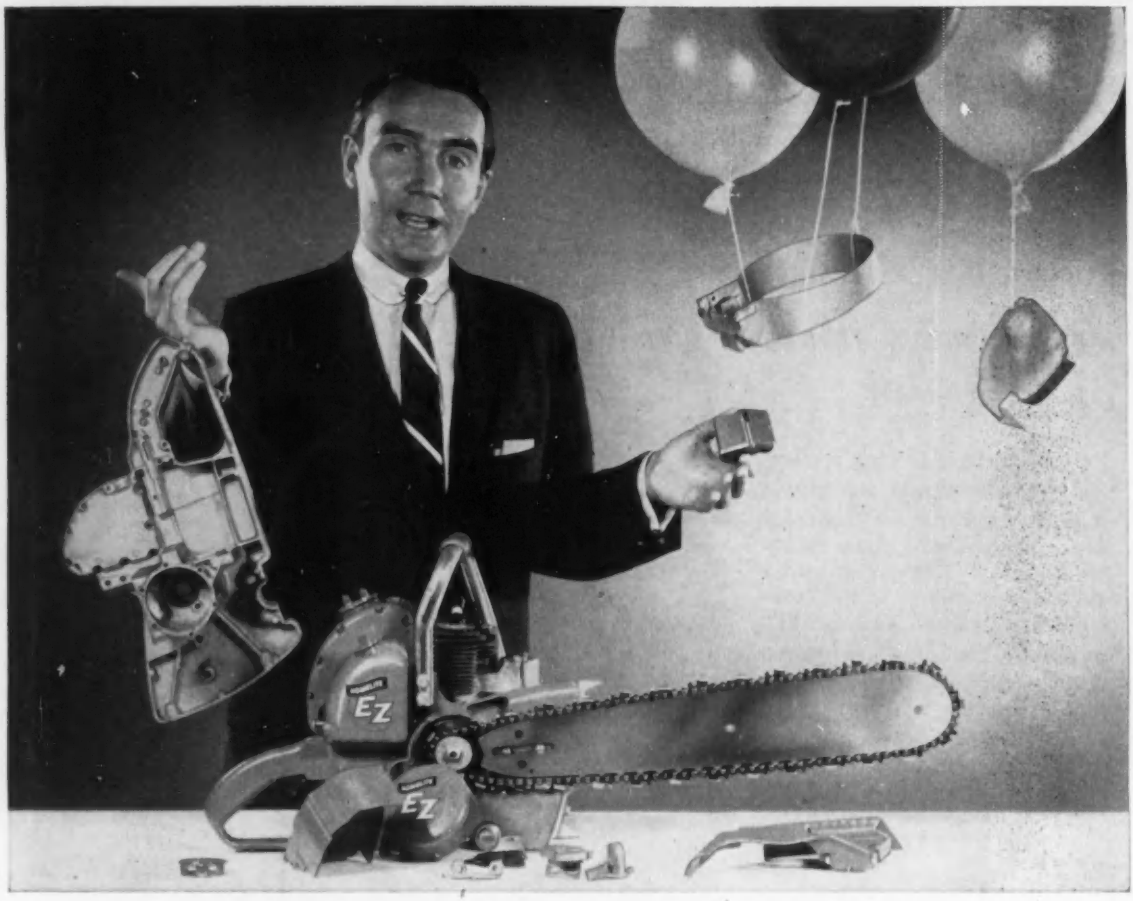


"So light, toy balloons can lift them . . ."

Bantam-weight Doehler-Jarvis Homelite pack 5 horsepower

The gasoline-engine-driven EZ is an eager little beaver . . . whips through an 18-inch pine in 14 seconds, an 8-inch oak in 5.

This just shows that magnesium die castings are the lightest of light.

And they are amazingly strong.

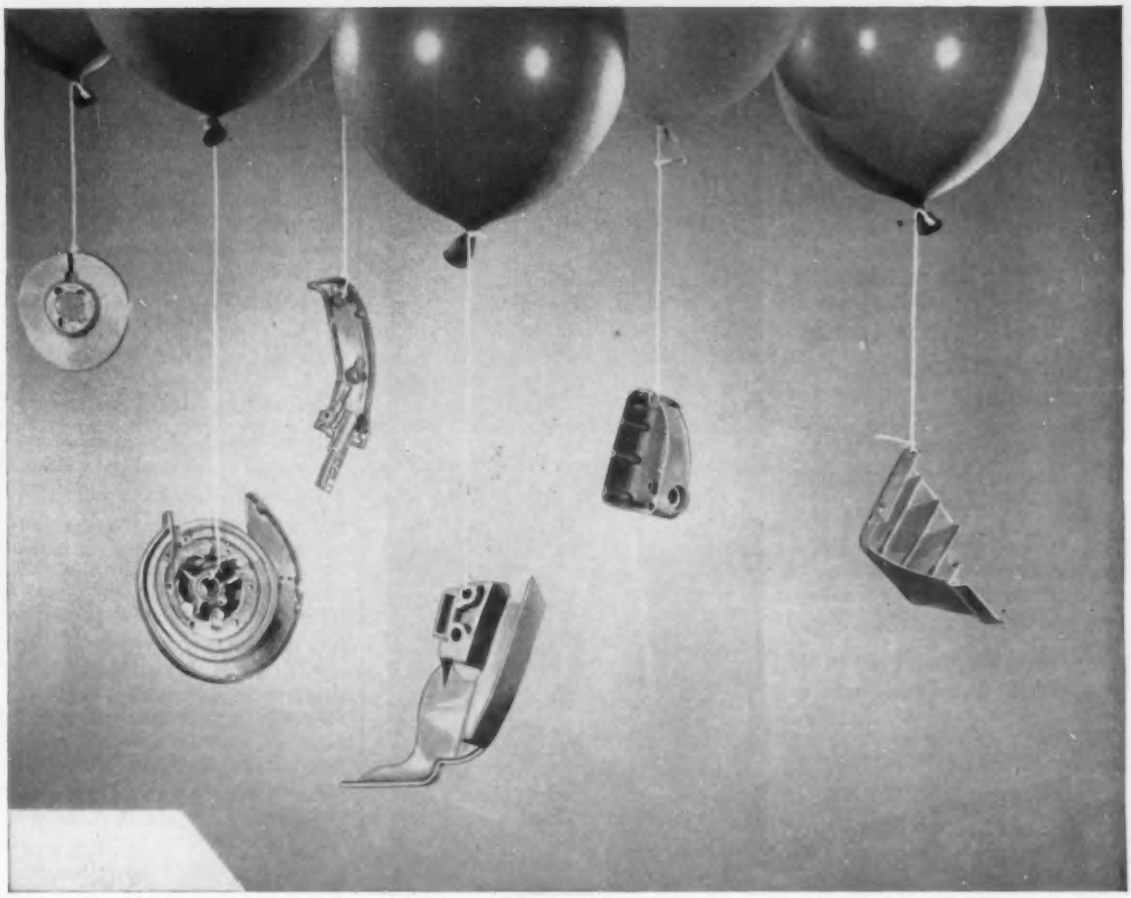
With these particular Doehler-Jarvis magnesium die-castings, for example, Homelite (division of Textron Inc.) packs 5 horsepower into their heavy-duty EZ direct drive chain saw and still keeps weight down to 19 pounds.

Design aids lightness, too

This sales-building lightness and strength is not based solely on the use of magnesium. Homelite and Doehler-Jarvis engineers also eliminate practically all excess metal. They do this by taking advantage of minimum thickness die-cast sections. Ribs provide rigidity.

They do away with much machining, too. And cast in several competitive advantages. For example:

- Die casting establishes accurate machining base points. These permit multi-jig production and both improve



magnesium die castings help into this 19-pound chain saw

dimensional accuracy and reduce cost.

- Servicing instructions in bas-relief are die-cast right into certain parts.

What's more, Doehler-Jarvis delivers the raw parts with near perfect "as cast" surfaces... surfaces that need only degreasing to accept a high-quality finish.

PA reports outstanding service

EZ sales got off the ground fast. Within weeks Homelite needed twice the projected quantity of castings. With a separate plant at Batavia, N. Y. for producing magnesium die castings, Doehler-Jarvis was able to respond quickly. Says Homelite's Purchasing Agent, "Those fellows out in Batavia have certainly done an outstanding job for us."

And you can be sure that Doehler-Jarvis *does* do outstanding work. Right now we're operating some 20,000 dies for some 1400 firms. Call us in on *your* next job.

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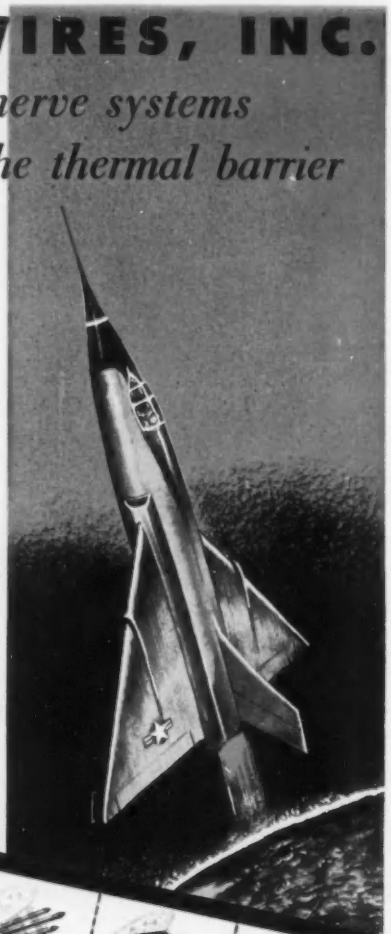

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value, the plunger operates the switch so that an electrical circuit is either closed, opened or transferred.

Switches are rated for 15 or 20 amp at 115 or 230 v a-c. D-c switches are also available. The switch is wired through a ½ in. NPT opening in the enclosure. United Electric Controls Co., 85 School St., Watertown, Mass.

For more information—
Circle 52, inside back cover

Ultra-Thin Metal Strip

Metal strip held to close thickness tolerances is produced in widths to 4 in. and in thicknesses from 0.010-inch down to 0.00012-in., with thickness guaranteed uniform to a tolerance of 0.00005 in. This cold-rolled strip is furnished in a wide range of metals, from the hard, high-temperature resistant alloys to the soft light metals. The company will roll the strip from metal furnished by the customer or will produce (melt, cast, forge and hot roll) the metal itself to specifications. Furthermore, the mill will slit this strip to smaller widths with closer tolerances than are commercially available (ribbons as narrow as 0.04 in., with widths held to a tolerance of ±0.001-in.). Allied Products Div., Hamilton Watch Co., Lancaster, Pa.

For more information—
Circle 53, inside back cover

Narrow Range Speed Control

This drive was designed for register control applications in the printing, packaging, textile and plastic industries and for metering and proportioning where extreme accuracy is needed. The micrometer dial provides 400 graduations in producing a speed variation of ±15 per cent of the input speed. Graham Transmissions, Inc., Menomonee Falls, Wis.

For more information—
Circle 54, inside back cover

Subminiature Pilot Lights

In this series of lights a figure, letter or word is hot-stamped into the flat face of the translucent plastic lens.

(Continued on page 263)

DESIGNING WITH ALUMINUM

NO. 22

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

ANODIZING ALUMINUM

One of the most appealing characteristics of aluminum is the ease with which a variety of surface finishes may be applied to it.

Among these finishes is one that is used almost exclusively for aluminum: anodizing. It is the electrolytic formation on the metal of an oxide film which is relatively thick compared to the natural oxide film formed in normal environments.

The natural oxide film, which begins to form on aluminum surfaces as soon as they are exposed to air, provides a thin, transparent, protective covering for the metal. This film, which may be only a millionth of an inch thick, accounts for aluminum's resistance to corrosion.

The thicker film produced by anodizing provides still greater anti-corrosion characteristics, plus a hard, wear-resistant surface. This anodized film may vary considerably in thickness, hardness and porosity, depending upon the anodizing process used. These processes are similar in that, in each of them, an electric current is passed between the aluminum and an electrolytic bath in which the aluminum is immersed as an anode. There are also distinct differences among the processes, such as the variety of electrolyte baths which may be used.

Sulfuric Acid Process

The sulfuric acid anodizing process is used to create a relatively thick, porous coating.

Sulfuric acid anodic films serve as excellent mordants for certain classes of dyes which, when absorbed in the coating pores, give bright attractive colors to the aluminum surface.

However, because most dyes will fade in direct sunlight, they should not be used in outdoor applications where fading over a period of several years may become a problem.

Relatively low cost makes this anodizing process the one most widely used commercially. Virtually all decorative anodizing is done in dilute sulfuric acid baths. Coatings produced by this process provide effective barriers to many corrosive atmospheres. Thin films produced in sulfuric acid are excellent surface pre-treatments for subsequent paint, enamel and lacquer coatings.

Because of the corrosive nature of the electrolyte, the sulfuric acid process should not be used for anodizing assemblies wherein bath entrapment might be possible.

Chromic Acid Process

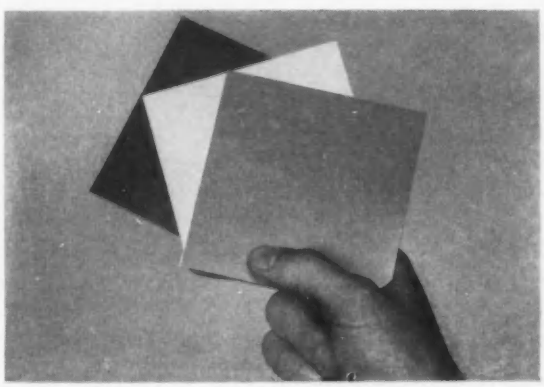
Anodic coatings produced in chromic acid baths are noted for their outstanding resistance to corrosion, which may be attributed to a lesser degree of porosity than sulfuric acid anodic films.

This reduced porosity limits the value of chromic acid coatings for dyeing, but they are widely used as base coatings for paints, enamels, etc. In fact, many armed services specifications include chromic acid anodic coatings as paint primers.

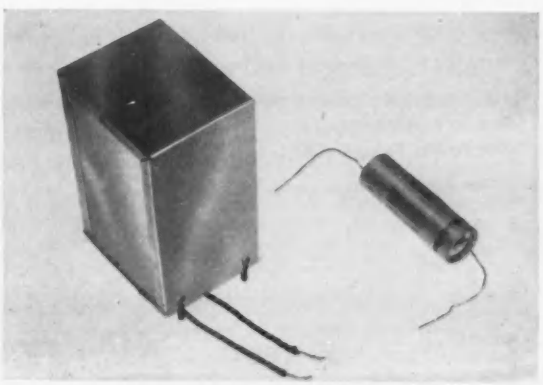
Although higher operating voltage requirements render this process more costly than the sulfuric acid process, it is frequently used for anodizing intricate shapes that are to be exposed to extremely corrosive environments. Because the bath acts as a corrosion inhibitor, there is no danger of corrosion being caused by bath entrapment in crevices.

Hard-Coat Processes

The hard-coat processes developed fairly recently are used to create heavy, highly abrasion-resistant films.



Anodized coatings can be formed in various shades ranging from colorless transparent to dark gray, depending upon the choice of aluminum alloy, electrolyte solution and anodizing conditions.



At one time, capacitors for use in electronic equipment were quite bulky (above left). Space and weight are now saved through use of anodized aluminum foil capacitors (above right) which are much more efficient.

With the added attribute of extreme resistance to corrosion, the hard-coats are especially useful in extending the service life of moving machinery parts. Hard-coats are currently being used on cylinders and pistons, hydraulic systems, textile machinery rolls and other applications requiring great wear-resistance.

To date, hard-coat processes are comparatively expensive. Both the voltage and current density used are quite high, and there is considerable expense connected with the refrigerating equipment required to maintain the bath temperature at about 30°F. or lower.

Boric Acid Process

Coatings formed by anodizing in boric acid solutions are nonporous, and have high dielectric strength.

Their use represents one of the specialized applications of the properties of anodic coatings. Etched aluminum foil, anodized in a boric acid solution, is now used in the production of electrolytic capacitors, or condensers. These are much more efficient and considerably smaller than earlier paper-wound capacitors. Their reduced size has had an important influence on the design of the compact radios, television sets and aviation electronic apparatus we use today.

Gold Coat Process

An improved anodizing process recently announced by Kaiser Aluminum makes use of a new decorative alloy to produce a striking gold color during anodizing. This gold color is remarkably lightfast —*far superior to dyes* in its resistance to ultraviolet light.

The anodizing processes that produce this gold color are low in cost and require only the standard equipment used in sulfuric acid anodizing.

Phosphoric Acid Process

Because the anodic oxide coatings formed in phosphoric acid are appreciably soluble in the anodizing bath, they are thin and highly porous—not sufficiently attractive to be used in decorative applications without subsequent finishing treatments.

An advantage of their thinness and porosity is in affording a good base for electroplating adherent layers of other metals, such as nickel, copper, silver and cadmium. In preparing pre-plating anodic coatings of this type, the anodizing characteristics of the individual aluminum alloys must be considered.

Desired results can be obtained by varying anodizing conditions such as bath concentration, temperature, voltage, etc. The most satisfactory plating solutions for use with phosphoric acid anodized coatings are those that are nearly neutral or only weakly acid or alkaline.

The processes described here are only a few of the many techniques used to create anodic coatings. There are many variables in each process, and specific control of all or any of the variables may be exercised to obtain certain desired effects. For further information concerning specific anodizing techniques, contact the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

ANODIZING CONDITIONS

Process	Bath Composition	Voltage	Current Density Amp/Ft²	Special Conditions or Equipment
Sulfuric Acid	15% H_2SO_4	14–17[1]	12	.....
Chromic Acid	5 to 10% CrO_3	0–40	1–5	Bath temperature 95°F.
Boric Acid	12%	500	10.8	Bath temperature 210°F.
Hard Coats	10–20% H_2SO_4	23 to 120	20–50	Refrigeration equipment to maintain temp. 25 to 30°F.
Phosphoric Acid	17–43% P_2O_5	5–30	10–20	Bath temperature 60–95°F.

[1] Depending on the alloy

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.

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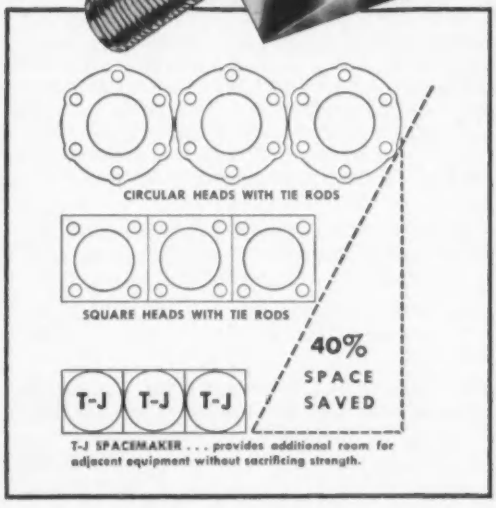

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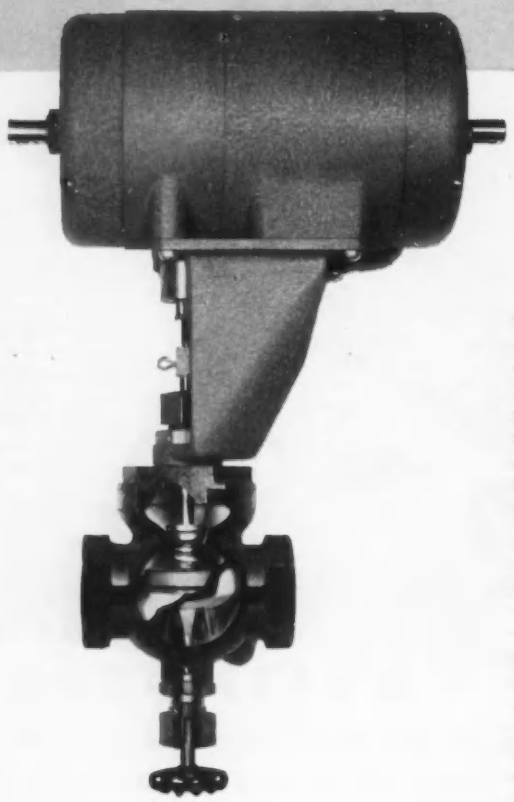
NEW ACTIONATOR*

heavy duty electric motor for operating valves, dampers, louvers



The new Honeywell ACTIONATOR is a compact, lightweight, rugged and flexible industrial motor for operating valves, dampers, louvers, and other final control elements. Models are available for mounting on, and operating rotary valves or dampers. The ACTIONATOR is also available with cam operator and yoke. Internal strain release protects valve seats and gear train so that it can be used on practically any slip stem valve.

The ACTIONATOR is a reversing capacitor type motor and provides on-off, two-position, floating or proportional control. Shaft rotation can cover up to 180 degrees in 7½, 30, 60, or 120 second timings; torque ratings from 50 to 200 inch-pounds depending on motor speed.

The proportional control model provides slidewire resistances of 100, 135 or 1000 ohms, and can be used with any type of electric proportional controller. A second slidewire can be used for retransmission . . . to operate another motor, or for remote indication. Spst and spdt auxiliary switches can also be installed within the end bells. The enclosed terminal compartment is designed to meet J.I.C. standards.

Limit and auxiliary switches, specially designed by MICRO SWITCH, allow the ACTIONATOR to be used where ambient temperatures range from −20 to +150 F.

For complete information and specifications on the new ACTIONATOR, call the nearest Honeywell office, or write (send coupon) to:

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Pa.

Industrial Division
MINNEAPOLIS-HONEYWELL REGULATOR CO.
Wayne and Windrim Avenues, Philadelphia 44, Pa.

☐ Please send me additional information on the ACTIONATOR.

☐ I'd like a Honeywell sales engineer to discuss applications of the ACTIONATOR in my plant.

Name_____

Title_____

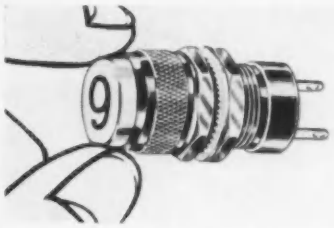
Company_____

Address_____

MINNEAPOLIS Honeywell

First in Controls

*Tradename Minneapolis-Honeywell Regulator Co.



The legends are filled in for sharp contrast. The spring-mounted lens assembly is made to rotate smoothly to permit positioning after the entire pilot light is screwed into place.

The lamp used in this light is the midget flanged base T-1-¾ incandescent lamp in any one of the following voltages: 1.3, 2.7, 6.0, 14.0 and 28.0 v. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. YY.

For more information—
Circle 55, inside back cover

Nylon Pellet Locks Fastener

The locking medium is a resilient, protruding nylon pellet permanently inserted in the body of the threaded part. When mating parts are engaged, the spring-like wedging action of the nylon pellet locks and seals the mating threads together. Nylok-Detroit Corp., 308 N. Woodward Ave., Birmingham, Mich.

For more information—
Circle 56, inside back cover

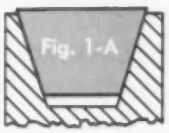
Packaged Industrial Controls

A line of industrial controls, providing automatic monitoring and control of virtually any chemical or mechanical condition that can be meas-

(Continued on page 264)

Why you get more service from V-Belts with CONCAVE SIDES

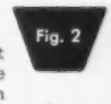
Each sidewall of a Gates V-belt is concave (Fig. 1)—a precisely engineered curve that makes V-belts last far longer.



HERE'S WHY: on the bend around the sheave, the concave sides of a Gates V-belt fill out and become straight (Fig. 1-A). Thus the belt makes full contact with the sides of the sheave, grips the sheave *evenly*. This even contact distributes wear uniformly across the sides of the belt.

Uniform wear lengthens belt life; keeps costs down.

MAKE THIS SIMPLE TEST



Bend a straight-sided belt (Fig. 2). The sides bulge at the bend causing uneven contact in the pulley groove (Fig. 2-A). Naturally, wear is greater at points indicated by arrows. Result: shorter belt life, increased belt costs.

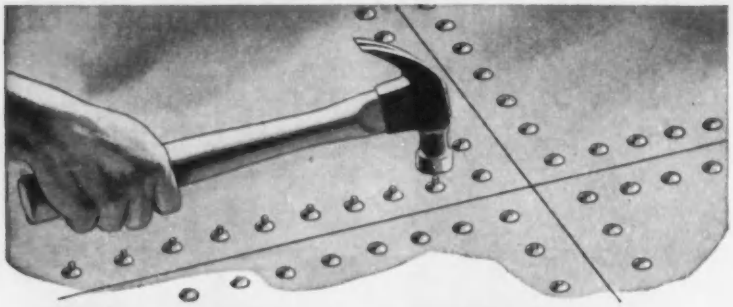
To cut down-time and V-belt replacement costs, specify belts that grip evenly and wear longer. Specify Gates Vulco Rope—the V-belt with concave sides. There is a Gates distributor nearby who will quickly supply the belts you need. The Gates Rubber Co., Denver, Colorado—*World's Largest Maker of V-Belts.*

There are Gates Engineering Offices and Distributor Stocks in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.

Gates

TPA 109

Gates VULCO ROPE Drives



The rivet you drive with a hammer!

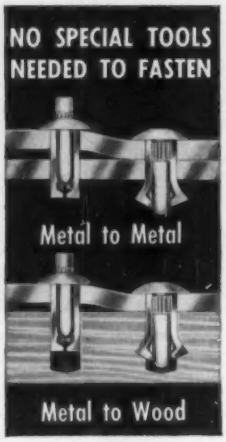
★STAR

PIN·GRIP DRIVE RIVETS

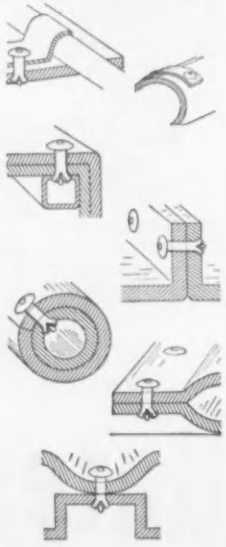
SPEEDS UP BLIND FASTENING! The Pin•Grip fastening method requires no special tools or skills and eliminates the use of costly, time consuming nuts, bolts or solid rivets.

Simply insert Pin•Grip into pre-drilled hole and drive the knurled pin flush with the rivet head with an ordinary hammer. Pin•Grip "pulls together" and locks materials into a permanent bond. Absorbs tensions, shocks, jars and vibrations.

Use Pin•Grip for every fastening application — metal to metal, metal to wood and compressible materials between panels. Just a few of the hundreds of uses for Pin•Grip are illustrated on the right. Available in a wide range of sizes in Universal, Countersunk and Full Brazier heads.



TYPICAL INSTALLATIONS



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Branch Offices with Stocks in Principal Cities

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Please send samples of PIN•GRIP and catalogs.
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Name_____
Firm_____
Address_____
City_____ Zone____ State_____

ured electrically, includes among the functions that can be controlled by the instruments voltage, current, torque, timing, pressure, temperature, liquid level, speed, depth, light, sound and deflection. The controls are effective over a variety of ranges for each function. Sensitivities begin with zero to 5 microamp or zero to 5 milliv. Normally the units operate on d-c, but they may be adapted easily to a-c in most cases.

Depending on the circuitry, the units will initiate desired control action either when an increasing or a decreasing signal reaches a preset point. Units also are available with both high and low limits. The controls are of the indicating type, calibrated in whatever units are applicable, with one pointer giving a continual reading of the signal from the operation being monitored. A second pointer may be turned to any place on the dial, usually a 95 deg scale arc, to fix the allowable signal limit. Control accuracy is held to within 2 per cent of dial settings.

Either on-and-off or locking (shut-off) control action may be selected on most units. With on-off, the device takes control action when the signal reaches the preset limit, but it continues to test the signal periodically. If a permissible signal level is reached, the unit stops its control of auxiliary equipment but continues to indicate the signal. With locking control, the device must be reset manually each time the signal reaches the control point. Tipp Mfg. Co., Tipp City, Ohio.

For more information—
Circle 57, inside back cover

Safety Relief Valve

A safety relief valve designed to withstand pressures up to 10,000 psi

(Continued on page 267)

Multiple sources for "Things" not called SPRINGS

Yours to put to work . . . . our mechanical ingenuity and craftsmanship . . . . experienced in producing an infinite variety of metal parts in such fields as automation, communication, medical, electronics, safety devices, product development, etc. The capacity of ASC springmaking minds and machines is unlimited. Ask any Division to examine your sample or blueprint.

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- BARNES-GIBSON-RAYMOND — 40300 PLYMOUTH RD. PLYMOUTH, MICH.
- B-G-R COOK PLANT — ANN ARBOR MICHIGAN
- SEABOARD Coil Spring Div. — 19001 S. BROADWAY GARDENA, CALIF.
- OHIO DIVISION — 1825 EAST FIRST ST. DAYTON, OHIO
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260% Greater Torque...

when your equipment is powered with Chrysler Industrial Engine and Chrysler Torque Converter

Here's a "natural" for any product requiring dependable power *plus* the means of automatically increasing *work ability* throughout the engine's speed range.

It's the Chrysler "power twins"—Chrysler Industrial Engine and Chrysler Industrial Torque Converter. Together, they make a lightweight, compact package offering high torque multiplication—up to 260% greater torque than you may be getting now—plus easy installation and trouble-free operation. Torque Converter features include dual cooling (liquid and direct air), and an optional built-into-housing output shaft governor control.

Chrysler Industrial Torque Converter is assembled with the Chrysler Industrial Engine of the manufacturer's choice. The combination may be ordered Chrysler-equipped for use with direct drive, transmission or power takeoff. Manufacturers may also specify high or low inertia flywheel—whichever best meets their requirements.

Check this power combination—Chrysler Industrial Engine (230 to 331 cubic inch displacement, in-line 6 or V-8), plus Chrysler Industrial Torque Converter. For more details see a Chrysler Industrial Engine Dealer, or write: ***Dept. 311, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

BUILT FOR EACH OTHER—CHRYSLER INDUSTRIAL ENGINE AND CHRYSLER INDUSTRIAL TORQUE CONVERTER

HORSEPOWER WITH A PEDIGREE

INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION

Chrysler INDUSTRIAL ENGINES

has a capacity of liquid flow at 25 per cent over pressure. It handles air, gas or liquid.

The valve body is an extra heavy carbon steel casting. The stainless steel inner valve parts are said to be constructed and assembled so that there is no stress around the seating area.

The valve is made in ½, ¾ and 1¼ in. sizes. It can be furnished in all stainless or other alloys for petrochemical service. Protek Specialty Co., P. O. Box 194, Bellaire, Texas.

For more information—
Circle 58, inside back cover

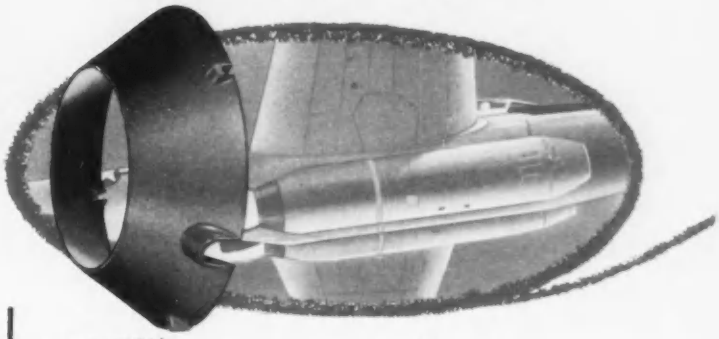
Vacuum Pressure Switch

Designed for airborne electronic systems, the series responds to pressure as low as 2 in. of mercury absolute and retains accuracy to ±1 in. of mercury pressure under extreme environmental conditions in aircraft and missile systems. The basic operating element in this switch design is the rigid miniature bellows. This bellows is sup-

(Continued on page 270)

THE SHAPE OF THINGS IN MOLDED SILICONE

SILI-CONE PROVES REAL COOL FOR JET AIRCRAFT EQUIPMENT



APPLICATION:
Thermal barrier for jet aircraft accessories.

PROBLEM:
The original part, along with drawings and molds, was presented to Acushnet by a well-known manufacturer of accessories for conventional and jet aircraft with orders to continue development with Dow-Corning 301 compound. The idea was to attain a part that would provide maximum physical properties at elevated temperatures of over 800°F.

SOLUTION:
Overcoming the high bulk factor of the compound was accomplished through the design and construction of a preform. Running the original mold in a special hydraulic ram equipped with controls permitting a wide range of temperatures and pressures, provided the necessary information in curing this compound. The resultant cure times and pressures enabled Acushnet engineers to design and construct a compression mold of hardened steel that made this part possible. Included in this project were small gaskets molded from Dow-Corning 301 that proved superior to metal in high heat insulating applications.

Pioneers in the advanced mold techniques and custom compounding of silicones, Acushnet now offers you immediate technical assistance in the molding and finishing of silicone resins.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

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ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS

... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING

Address all communications to 768 Belleville Ave., New Bedford, Mass.

Skagit Yarder-Loader, familiar sight around Northwest logging operations, moves ponderous logs with ease and agility because of rugged yet light-weight boom of Mayari R.

"Materials-handling" in the great North woods

In the sprawling timberlands of the Pacific Northwest they fell the raw materials for lumber, plywood, pulp and matches. Pulling the giant logs to a landing and loading them on big trucks is the job of mobile loggers designed and built by Skagit Steel and Iron Works in Sedro Woolley, Washington.

The logs are heavy and the going's rough, so these mobile loggers must be rugged yet highly maneuverable. To cut down unnecessary weight, Skagit builds the lifting booms from angles and channels of Mayari R low-alloy, high-strength steel. Because Mayari R has a substantially higher yield point than carbon steel, an amply strong boom can be built with lighter members. Skagit shop men find that they can weld Mayari R as readily as regular carbon steels, with the same general procedures. And Mayari R has from 5 to 6 times greater resistance to atmospheric corrosion, a distinct advantage under damp forest conditions.

All the significant properties of Mayari R, along with dozens of case histories and application photographs, are interestingly set forth in Catalog 353. If you would like to have a copy just get in touch with the Bethlehem district sales office nearest you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corp. *Export Distributor:* Bethlehem Steel Export Corp.

Mayari R...High-Strength, Corrosion-Resisting Steel

BETHLEHEM STEEL

GOLD N RING ... a new name and a new conception of CONTROL SWITCH design

HEAVY-DUTY

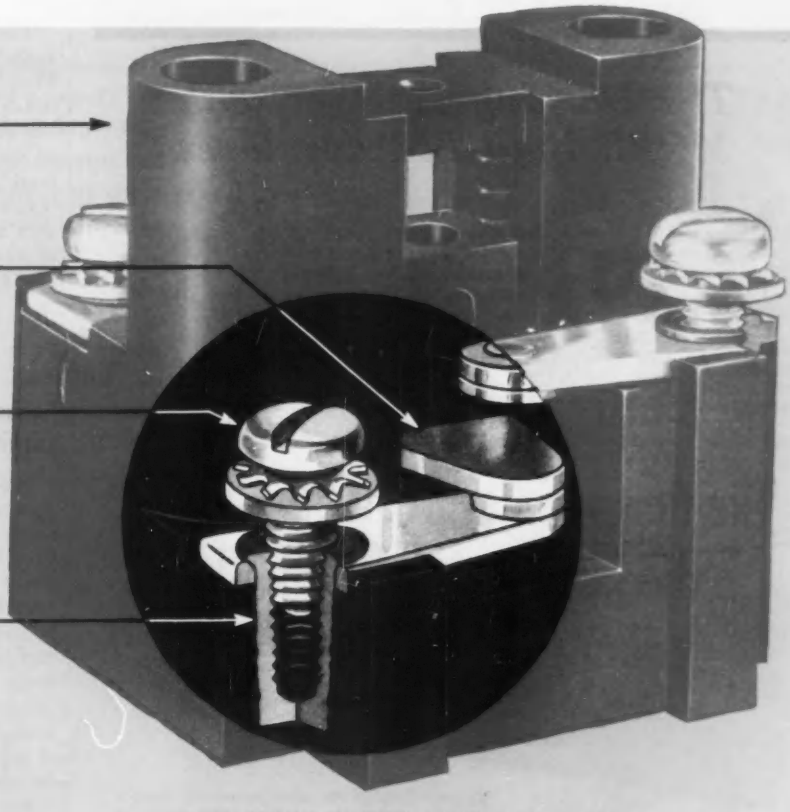
OIL-TIGHT—WATER-TIGHT—DUST-TIGHT

made by machine tool builders to machine tool specifications

A new name—GOLD-N-RING Sealtight Control Switch! A new conception—a control switch *designed and built BY a manufacturer of machine tools—FOR machine tool builders!*

A product of the same machine tool background responsible for Namco Solenoids and Snap-Lock Limit Switches, it gives designers a *package of greater electrical efficiency*—available from a single source, with a single source responsibility.

Shown here are only a few of many reasons why the GOLD-N-RING Control Switch makes it possible to match machine tool mechanical ruggedness with equally durable electrical efficiency.



1. **MAIN BLOCK** is unit-molded to assure alignment and simplify assembly.

2. **HEAVY-DUTY SILVER-ALLOY CONTACT POINTS** for maximum electrical capacity and long life.

3. **HEAVY-DUTY TERMINAL SCREWS**, with 3/8" thread contact, prevent stripping during installation; permanently secure wires for continuous trouble-free service.

4. **BRASS INSERTS MOLDED IN THE BLOCK** permanently hold stationary contacts. They also provide more thread support for the No. 8-32 terminal screws that are equipped with captive flat and lock type washers.

For complete details, send for Bulletin ECS-56. Better yet, ask for a representative to bring a switch for your examination.

ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL ACME COMPANY • 170 EAST 131ST STREET • CLEVELAND 8, OHIO

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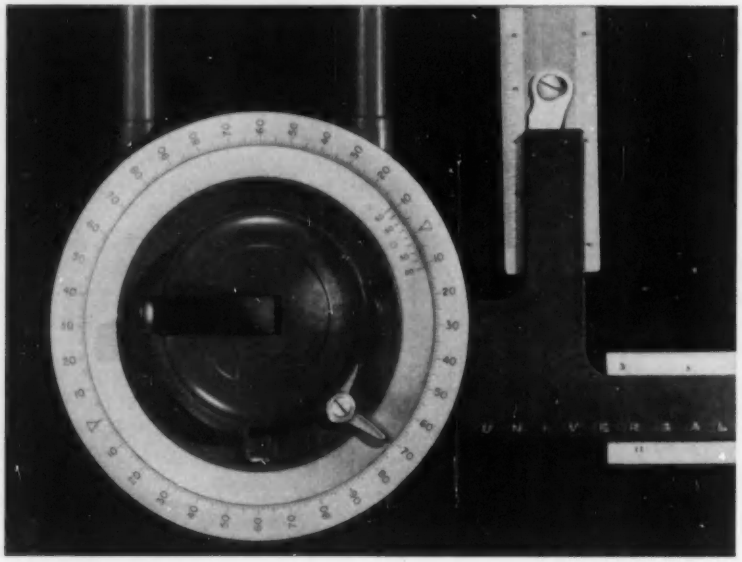

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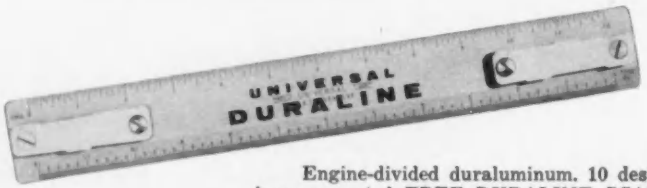
Only Universal features the protractor OVER the arm for 100% visibility. Blind readings are eliminated and controls cannot be lost under the arm struts. The Boardmaster controls are large in size and compactly grouped for comfortable, easy operation. Ask your dealer about these and MANY more Boardmaster advantages . . . or write for illustrated bulletin. See for yourself why Universal Boardmaster is *preferred* by engineers and draftsmen all over the world!

The first word in SCALES... the last word in PRECISION!



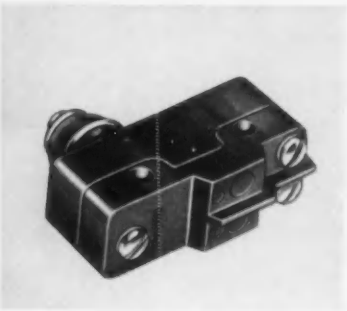
Engine-divided duraluminum. 10 design improvements! FREE DURALINE SCALE SELECTOR. Ask your dealer or write direct.

FIRST SINCE 1901

UNIVERSAL
DRAFTING MACHINE CORPORATION
7960 LORAIN AVENUE • CLEVELAND 2, OHIO

ported in a manner which enables it to resist self-actuation under severe vibration up to 2000 cps at 10 G. This switch (less than 3 oz) has an approximate over-all length of 3½ in. Gorn Aircraft Controls Co., 845 Main St., Stamford, Conn.

For more information—
Circle 59, inside back cover



Split-Contact Switch

This snap-action switch is useful for applications up to ¾ hp. Although the Model C-11008 is a normally closed switch, the double-throw arrangement can control two single-throw circuits, or can be used for double make or break in a single circuit. Rating of the switch is 15 amp and it is furnished with a pin plunger or any other type of actuator. Acro Mfg. Co., Columbus 16, Ohio.

For more information—
Circle 60, inside back cover

Close-Tolerance Limit Switch

Exact limitation of rotary motion is assured by the use of two cams that are driven along a rotating lead-screw to actuate two single-pole, double-throw switches. Lead screw is connected to the system to be controlled by suitable gears. Adjustability of one part in 3400 (0.03 per cent of the full range) is possible, and repeatability of ±5 deg of a 360 deg revolution of the lead-screw (0.04 per cent). The limit of travel for the cams is from one to 70 turns of the lead screw.

Limits are set by pulling the calibrated scale bar forward to disengage the teeth on the perimeter of the cams, rotating the cams on the lead-screw to the desired limits, and al-

(Continued on page 273)

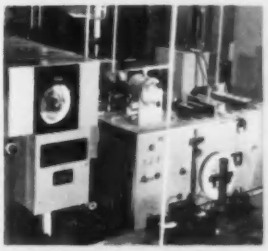
another basic reason why industry prefers

OHMITE®
COMPONENTS

better quality through more advanced research and testing!

Behind every Ohmite component is a bulwark of *advanced* research and testing laboratories. These laboratories use the finest scientific instruments and equipment. Here Ohmite products are tested and retested under the most grueling conditions to detect possible sources of trouble. And these same laboratories are used for the development of new materials, new processes, and new designs . . . to build *reliability* into Ohmite products that set new standards for long life and trouble-free performance.

High temperature globar furnace; muffle furnace for enamel testing; hydrogen atmosphere sintering furnace.



Humidity chambers using program-controlled cycles; here Ohmite products are tested under a wide range of temperature and humidity conditions.

Microscopic and petrographic equipment used in Ohmite laboratories for optical examination of materials and products.

Microscopic analysis of structure using metallograph. Thermal expansion of ceramics and vitreous enamels can be determined with interferometer equipment.

Instruments shown above are used to check and standardize the many pieces of Ohmite electrical test equipment.

This power panel provides AC or DC in a wide range of currents, voltages, and frequencies . . . permits testing Ohmite products under operating conditions.

X-ray Diffractometer and X-ray Fluorescence Spectrometer make possible the determination of crystal structure, as well as elemental composition of materials and products by means of X rays.

Be Right with..

OHMITE®

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS

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3611 Howard Street, Skokie, Illinois

build reliability into your product with OHMITE® COMPONENTS

close-control RHEOSTATS

All-ceramic and metal, close-control rheostats for unsurpassed dependability and smoothness of operation. Ten stock sizes, 25 to 1,000 watts.

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A wide range of dependable, fixed, adjustable, tapped, and noninductive power wire-wound resistors. Also a wide range of precision resistors.

general-purpose RELAYS

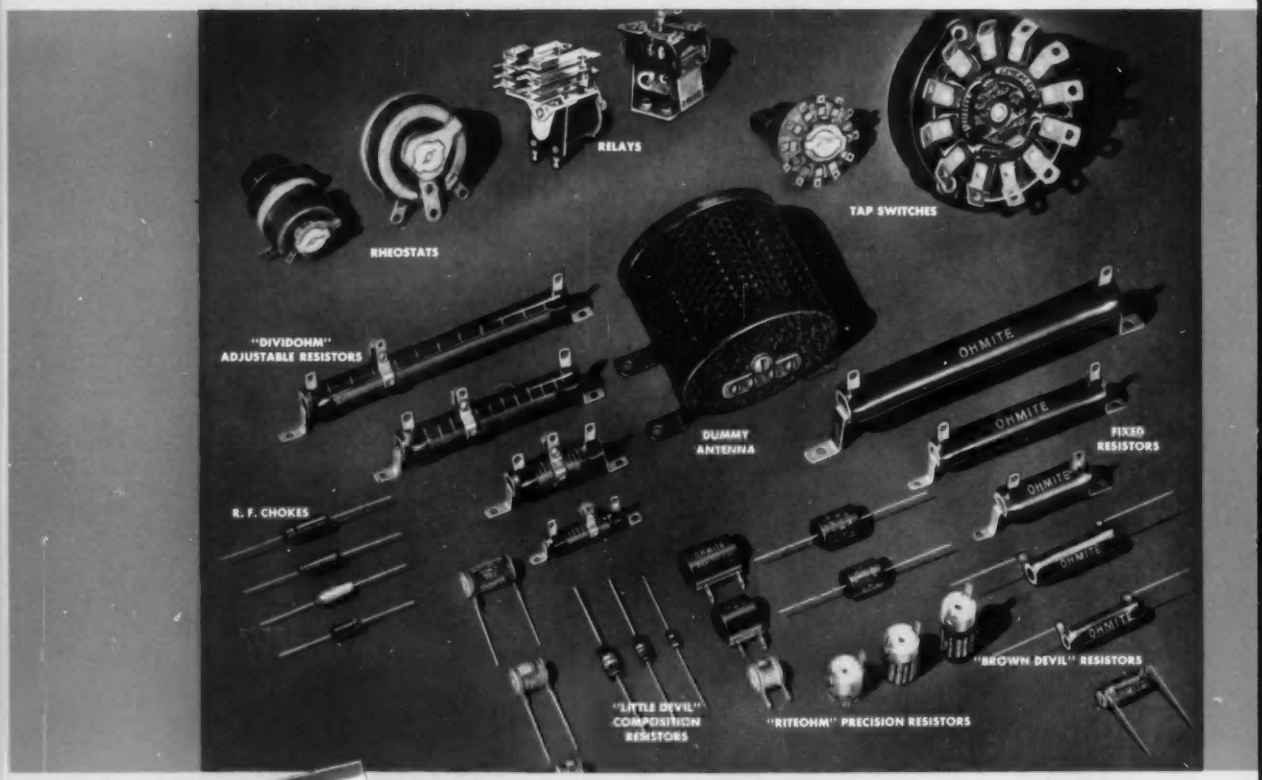
65 Types in four stock models. Good delivery on made-to-order relays. Contact current ratings up to 25 amps, AC or DC. Wide variety of contact arrangements. Hermetically sealed or dust-protective enclosures available.

high-current TAP SWITCHES

Five compact models, up to 100 amperes, AC, up to 12 taps. All-ceramic and metal construction. Silver-to-silver contacts, with self-cleaning rotor contact.

radio-frequency CHOKES

Single layer R.F. plate chokes and power line chokes on steatite or plastic cores. Protected by a special moisture-resistant coating.



WRITE on Company Letterhead for Catalog and Engineering Manual.

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RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS

OHMITE MANUFACTURING COMPANY • 3611 Howard Street, Skokie, Illinois

lowing the scale bar to spring back to its original position. Cam settings are read directly on the scale bar, which is calibrated in revolutions of lead-screw.

The base of the assembly measures 4⅛ x 2¾ x 1⅛ in. wide. Arch Instrument Co., Inc., 101 Holmes St., N. Quincy, Mass.

For more information—
Circle 61, inside back cover

Polyurethane Foam Materials

A line of polyurethane foam can be supplied in rolls, sheets or slabs in thicknesses from ⅛ to 12 in., and widths up to 48 in. The line includes ten resiliencies, from very soft to very firm in any shade of the seven basic colors. Texas Foamed Plastics Corp., Gonzales, Texas.

For more information—
Circle 62, inside back cover

High Sensitivity Relay

Sensitivities from 0.2 microamp to 10 amp are possible, or 0.1 milliv to 500 v. A-c relays have built-in silicon or germanium diodes, or copper oxide

(Continued on page 276)

ACE-HIDE®

the new molding material that's both **TOUGH** *and* **GENTLE**

Ace-Hide acid pail

Molded top for golf bag

Large molding is lid for beverage cooler

Ace-Hide is a new rubber-plastic molding material designed to take a beating without showing it. Its toughness, smoothness, resilience and excellent chemical resistance have already led to wide-spread use for things like chair arm pads, scuff guards, acid pails and golf bag tops.

Ace-Hide is a special blend of rubber with plastic, hence is light in weight and has good electrical and thermal insulating properties. Rigidity and impact strength (to 10.0 Izod) can be varied to suit. Takes inserts well. Surface is smooth, shiny. Does not develop flexing cracks, and ages well. Ace molding facilities offer wide range of sizes and shapes. We'll be glad to make specific recommendations. Write today.

Ace-Hide and many other hard and soft rubber, plastics, and rubber-plastic blends are described in 80 pg. ACE Handbook. Write for your copy today!

ACE® rubber and plastic products

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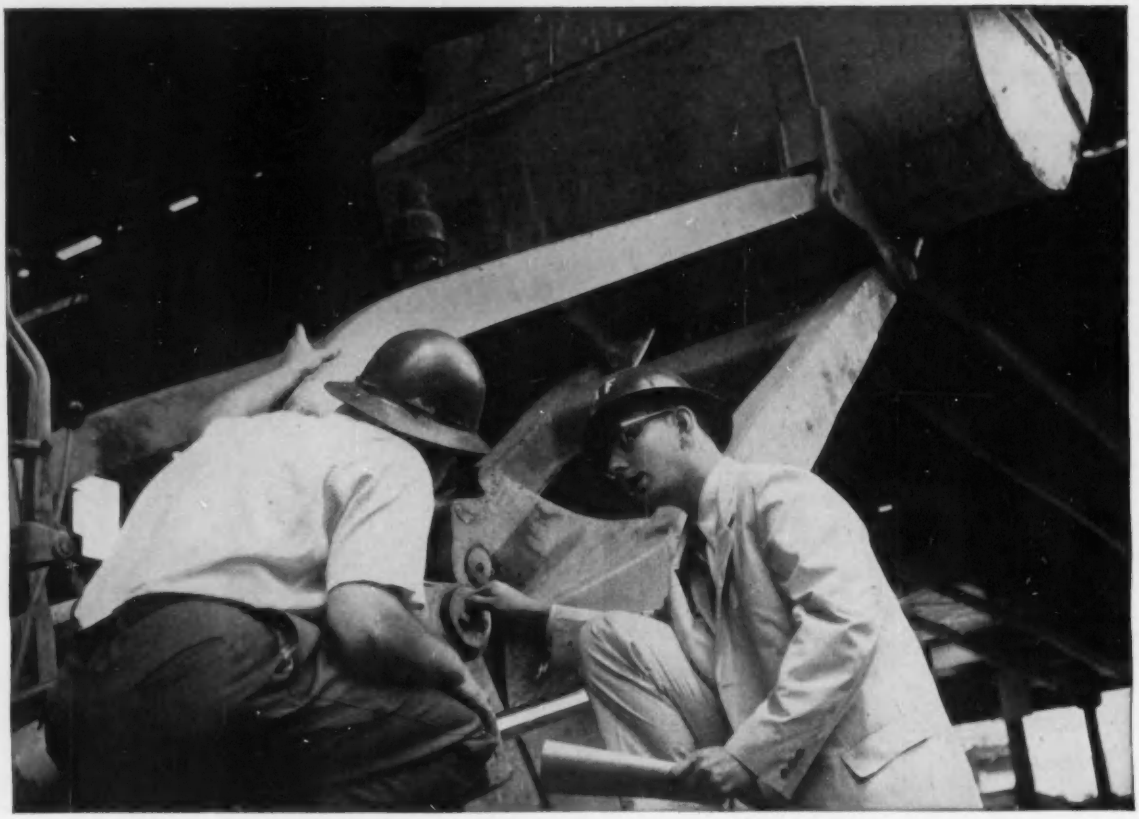

Why the trend to heat-treated cap screws in the heavy equipment industry?

Chicago Screw engineers worked with leading manufacturers to develop the high-strength, heat-treated screws that take more punishment and greatly reduce fastener costs

Strength, and the ability to withstand severe punishment, are prime requirements for fasteners used in heavy equipment. As a leading fastener source for most of the top manufacturers of heavy equipment, CHICAGO SCREW conducts a thorough research and development program aimed at steadily improving fastener performance.

A major result of this program is the development of the CHICAGO *carbon-restored* heat-treated cap screw, now replacing bright-finish fasteners for most heavy equipment applications. Design engineers have found the far greater tensile strength of the heat-treated fastener (see chart) gives a better fastening with fewer—or smaller—screws. This means less weight . . . and a considerable reduction in fastener costs.

In addition to greater strength, CHICAGO heat-treated cap screws prove far superior in withstanding fatigue, wear, shock and vibration. This is because a major cause of fastener failure—a surface layer of soft, decarburized steel—is eliminated by our unique Carbon Restoration process. Vital surface carbon is restored in a scientifically controlled process during final heat-treating, producing a fastener that's uniformly hard from core to surface.

Our engineers will be glad to advise you on designing to best take advantage of heat-treated cap screws. For complete information on cost savings you can get in your products . . . and a detailed version of the condensed tensile strength chart at right . . . drop a line to our Standard Products Division.

HOW TENSILE STRENGTH COMPARES

Diameter (Coarse Thread)	Bright Cap Screws Tensile Strength (Pounds)	Heat-Treated Cap Screws SAE Grade 5 Tensile Strength (Pounds)
¼	2,150	3,810
5/16	3,550	6,270
3/8	5,250	9,280
7/16	7,200	12,720
½	9,650	17,000
9/16	12,400	21,800
5/8	15,400	27,070
¾	21,400	40,100
7/8	29,500	53,040
1	38,700	69,590

THE CHICAGO SCREW COMPANY

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872
2507 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

Let an O-M Field Representative Help You Iron Out *Fluid* Power Problems

The best way to solve your cylinder problems is to discuss the problems with your O-M Field Representative in your own plant or office.

Whether you are using air or hydraulic power, your O-M Field Representative can be of valuable assistance to you. His broad experience with cylinder applications and installations qualify him to recommend the air or hydraulic cylinder best suited to your particular application.

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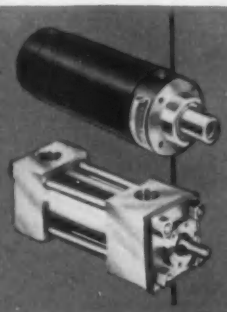
WOMACK MACHINE & SUPPLY CO.
Dallas, Texas

ZOPF ENGINEERING CO.
Kansas City, Missouri



O-M tie-rodless (Round Line) air and hydraulic cylinders—rated to 500 psi Air; to 1500 psi Hydraulic.

Series TH (Square Line) hydraulic cylinders—rated to 2000 psi.

Both lines of cylinders are available in complete range of sizes (1 1/2" to 8" bores) with standard or oversize rods.

ORTMAN-MILLER MACHINE COMPANY
15 143rd Street, Hammond, Indiana

- ☐ Have Field Representative call
- ☐ Send Bulletin 105 (Square Line)
- ☐ Send Bulletin 101A (Round Line)

Name_____ Position_____

Company_____

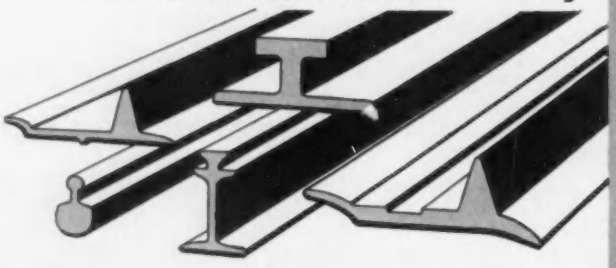
Address_____

City_____ Zone_____ State_____

WHY DO THIS . . .

WHEN YOU CAN DO THIS

Your requirements done the modern way



Here are a few specialties that WEST VIRGINIA WORKS roll.

SPECIAL SECTIONS ARE VERSATILE

Manufacturers are finding it vastly profitable to use special sections for hundreds of different production purposes. Many jobs, now being produced by hand, can be rolled to your exact specifications. This cuts out costly machining and hand labor. Some have cut production costs in half by using specially rolled sections. Inquire about this money-saving, time-saving production method.

Write or Call for FREE ENGINEERING CONSULTANT *Service!*

West Virginia Works
CONNORS STEEL DIVISION

H. K. PORTER COMPANY
P. O. Box 316 HUNTINGTON, WEST VIRGINIA
HKP

rectifiers. Trip point accuracy varies from 1 to 25 per cent, depending on the specifications.

Contact ratings are from 5 to 125 milliamp, d-c. Assembly Products, Inc., Desert Hot Springs, Calif.

For more information—
Circle 63, inside back cover

Finish for Die Castings

This finish is designed to produce a uniform dense black finish on zinc, cadmium or zinc-base die castings. The process involved is fast, can be conducted at room temperature, requires no exhaust equipment, and features a cycling period which can be adjusted to automatic machine operation.

The base chromate coating of a metal to be finished can be made thicker, denser and harder than those obtained by previous methods, and the result is a greater absorption of this new coating. Conversion Chemical Corp., Rockville, Conn.

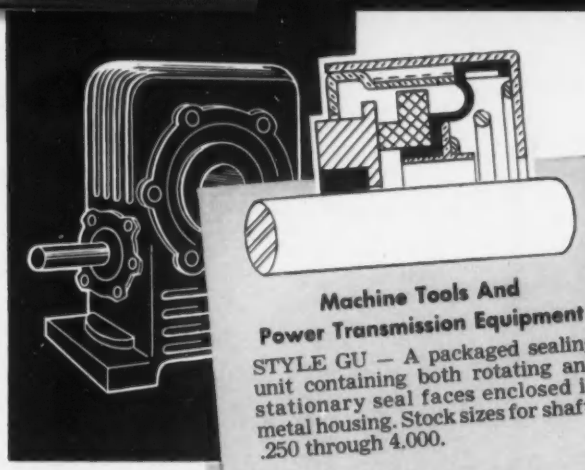
For more information—
Circle 64, inside back cover

Aluminum Packing Gland

These packing glands are machined from 24S-T4 aluminum, and designed for sealing wires, tubes or rods of any material. They are also made of Type 303 stainless steel.

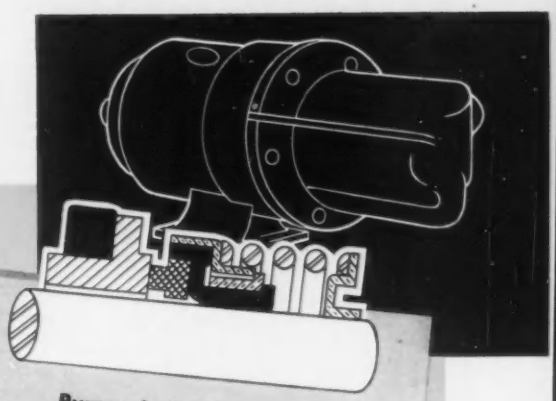
Bore diameters of $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$ and $\frac{5}{16}$

(Continued on page 280)



Machine Tools And Power Transmission Equipment

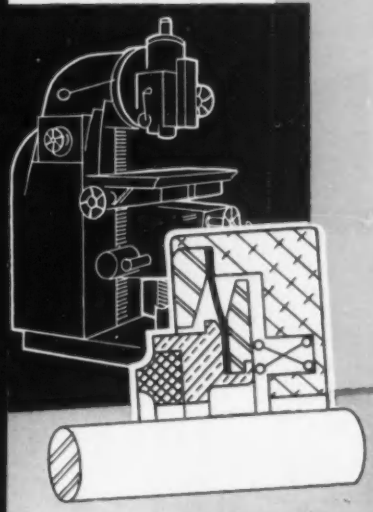
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

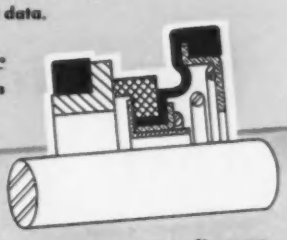
A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

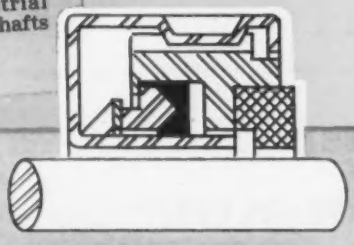
1038S South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



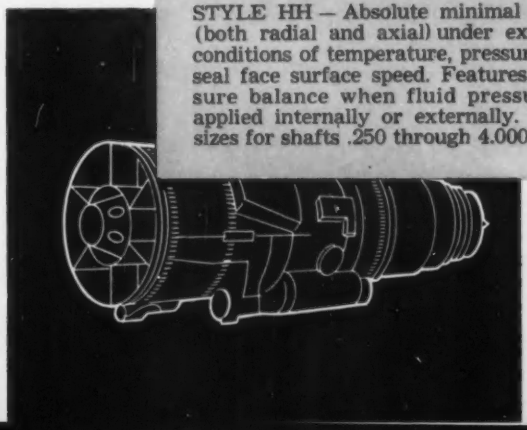
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



- FROM -
MADISON-KIPP CORP.
MADISON, WIS.
DEEP-DOWN SECURITY
Good housekeeping and excellent metal control have given Madison-Kipp a most outstanding record on both ordnance and commercial products in zinc and aluminum for over a quarter of a century.
kipp
MADISON-KIPP CORPORATION

ONE LABEL FOR **AL.**

TWO LABELS FOR **ZN.**

Significant Labels *of modern metal founding at the* Die Casting Division *of*

MADISON-KIPP Corporation

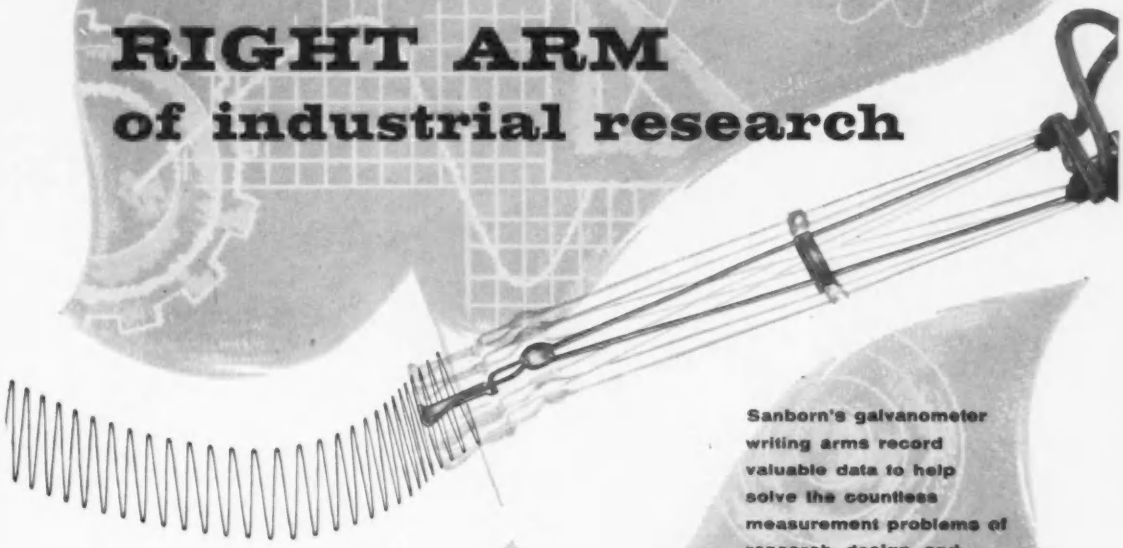
Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION
204 WAUBESA STREET • MADISON 10, WIS., U.S.A.

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

RIGHT ARM
of industrial research



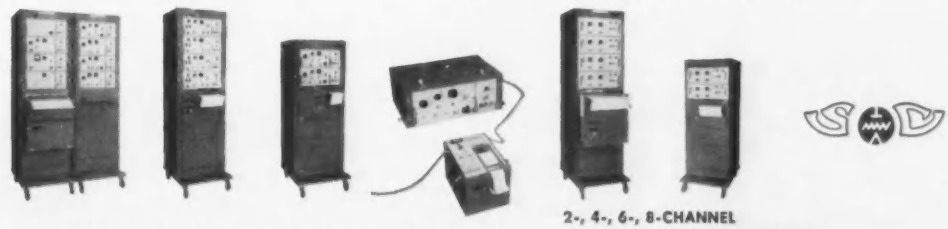
Sanborn's galvanometer writing arms record valuable data to help solve the countless measurement problems of research, design, and production testing.

SINGLE to 8-channel inkless and permanent recording in true rectangular coordinates of 0-100 cps phenomena — ranging from telemetered aircraft data to atomic reactor characteristics — is the vital and growing role of Sanborn oscillographic recording systems in industry. The Sanborn file of users indicates that such recordings are aiding in the dynamic analysis of jet engine starters, machine tools, agricultural machinery and oil drilling equipment; performance of pilotless target aircraft, modern submarines and tracking radar systems; and the production testing of servo components, valve positioners and precision potentiometers. Sanborn systems designed especially for recording analog computer output extend applications further — in simulated flight set-ups, solution of complex problems with six or eight variables, etc.

The advantages of making Sanborn equipment the "right arm" of *your* recording problems include extreme *flexibility*, by means of a dozen different interchangeable, plug-in "150 Series" preamplifiers which quickly and economically adapt a basic system to changing requirements; choice of 1-, 2-, 4-, 6- or 8-channel systems, in vertical mobile cabinets or "portably packaged"; numerous chart speeds, many individual channel controls, and high over-all system linearity.

To see how oscillographic recording the Sanborn way can become the "Right Arm" of *your* analysis work, write for detailed information or contact your Sanborn Representative. Sixteen-page "150 System" catalog on request.

SANBORN COMPANY
Industrial Division, Cambridge 39, Mass.



8-, 6- CHANNEL | 4-CHANNEL | 2-CHANNEL | 1-CHANNEL | 2-, 4-, 6-, 8-CHANNEL ANALOG COMPUTER SYSTEMS

From huge aircraft engines to tiny precision instruments—there's no end to the variety of products improved by Perkins custom-cut Gears!

Perkins is a *gear engineering* organization with a 35 years' tradition of New England craftsmanship as background. As one of the country's largest producers of gears to customers specifications, Perkins will meet your specific requirements for gears—regardless of size, type, material or quantity desired, *and at competitive prices*. You furnish the specifications, we'll produce the gears.

PERKINS MAKES in all materials, metallic or non-metallic, and in any size, to your specifications: helical gears, bevel gears, sprockets, ratchets, worm gears, spur gears with shaved or ground teeth, ground thread worms.

NOTE: The **PERKINS PRECISION SPRING COILER** is the latest development in the spring coiler field and eliminates entirely the use of arbors and long set-up time. It is a complete self-sufficient machine and enables you to make the spring you want *when* you want it — in seconds. The coiler produces any type of spring, in any diameter and any pitch with this range: Wire Sizes .005 to .125. Diameter from 3/32" to 12" and larger. Size of the compact coiler is only 7½ x 16". **A POWER MODEL** mounted on a welded steel console cabinet base is also available. Full information on request.

Perkins Machine & Gear Company
105 Circuit Ave.
West Springfield, N. Y.

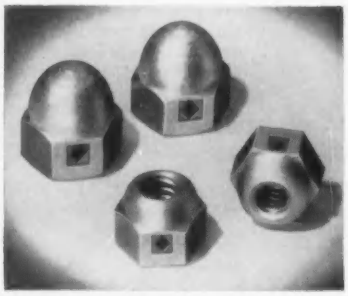
in. are available. Sealants are of neoprene, lava, Teflon or asbestos-graphite. Conax Corp., 7811 Sheridan Drive, Buffalo 21, N. Y.

For more information—
Circle 65, inside back cover

Absolute Air Pressure Switches

These pressure switches are designed for aircraft, guided missiles and other pressure control applications where wide temperature ranges, shock and vibration are important factors. Weight is 2¼ oz. Electrical rating is single-pole, single-throw, rating 110 v a-c; 28 v d-c, 5 amp, non-inductive. Accuracy is said to be ±½ psi. Newark Controls Co., 15 Ward St., Bloomfield, N. J.

For more information—
Circle 66, inside back cover



Self-Locking Cap Nuts

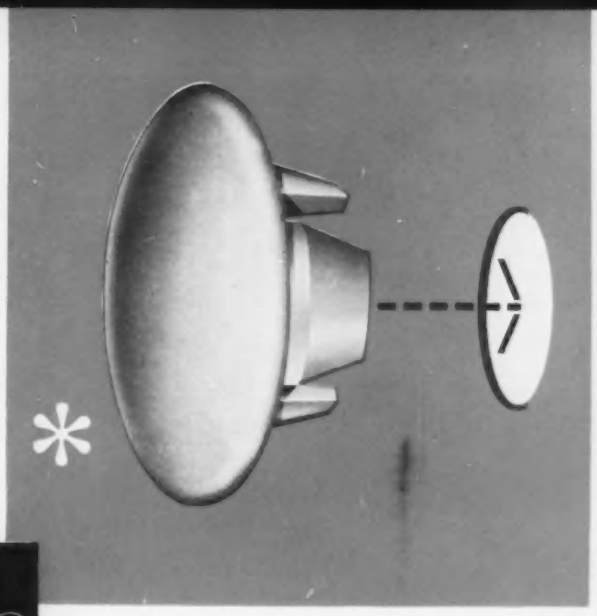
These nuts have a resilient pellet of nylon permanently imbedded in each nut. The pellet projects beyond the threads and, when engaged, is compressed by the mating threads. These

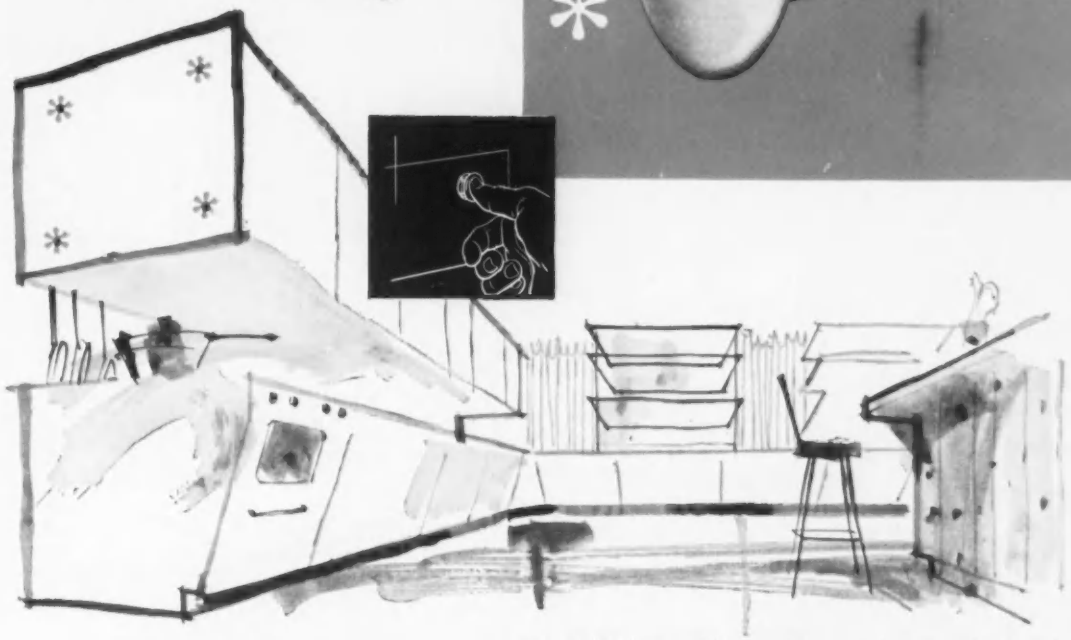
(Continued on page 284)

Good looks count

. . . and you can count on improved product appearance with

Plasti-Plugs®

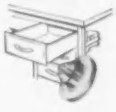




Plug production holes

Ventilation plugs

Cover access holes



Silent drawer glides

Metal kitchen cabinets with unsightly production holes showing? Not if Fastex Plasti-Plugs (one piece, self-retaining hole plugs) are used! Snapping-in with a light touch of the finger, Plasti-Plugs are available in 45 standard sizes, in colors to match every product. Low in cost to buy and apply, Plasti-Plugs do double duty too—can be used for dust protection, friction glides and as replaceable plugs. Special moisture-sealing plugs may also be had. Made of polystyrene, nylon or vinyl, they're non-corrosive, always good-looking.

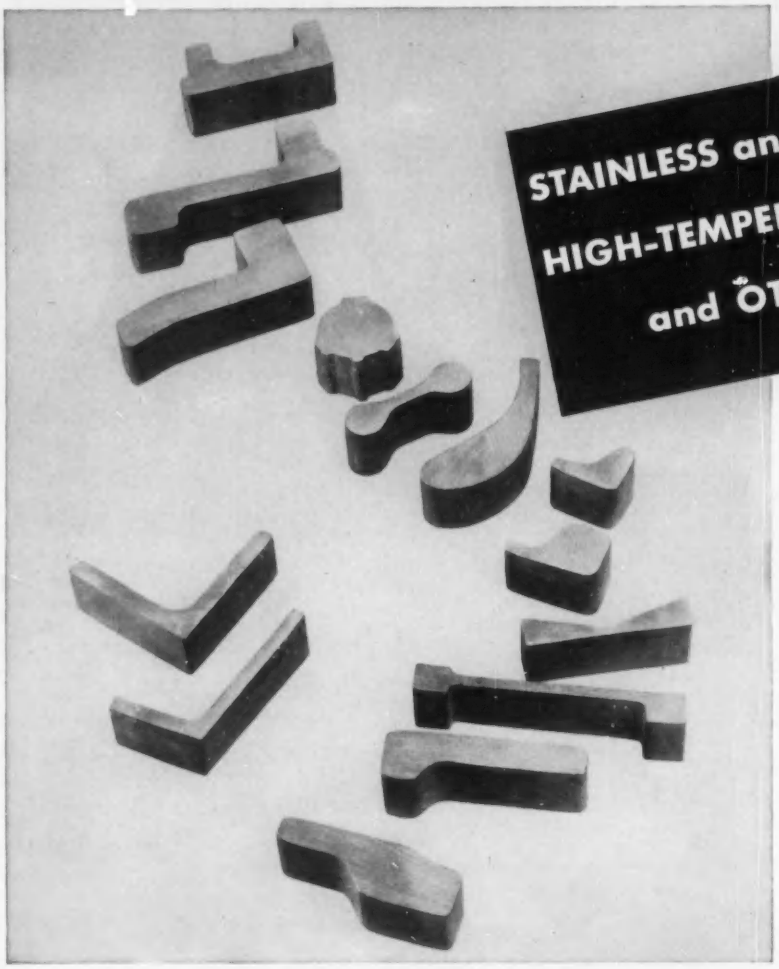
Write for free catalog. **45 standard sizes** listed . . . tells how easily you can "snap in" Plasti-Plugs by Fastex.

FX Trade Mark

FASTEX

195 Algonquin Road, Des Plaines, Illinois
In Canada: Canada Illinois Tools Limited, Toronto, Ontario

FASTEX SHAKEPROOF **DIVISIONS OF ILLINOIS TOOL WORKS**



STAINLESS and TOOL STEELS
HIGH-TEMPERATURE ALLOYS
and OTHER STEELS

A-L HOT EXTRUSIONS (solid and hollow) may solve problems for you

Help! (Dept. PE-83)

We have a parts problem that hot extrusions might solve. Let's see an AL representative for facts and figures.

- ☐ STAINLESS STEEL
- ☐ TOOL STEEL
- ☐ HIGH TEMPERATURE STEEL
- ☐ OTHER STEELS

Name_____

Company_____

Address_____

Where can these leading advantages of hot-extruded special alloy steels apply to your production?

1. Hot extrusions require very little finishing before use, even in the case of involved shapes. The scrap loss is small and you can buy raw materials closer to finish size. You buy less high-cost steel, cut away less of it . . . save both in time and material cost.

2. The range of shapes, solid or hollow, which can be hot-extruded is almost infinite. They can be easily and quickly produced in any quantity. Dies for new or experimental parts cost little and can be made up fast.

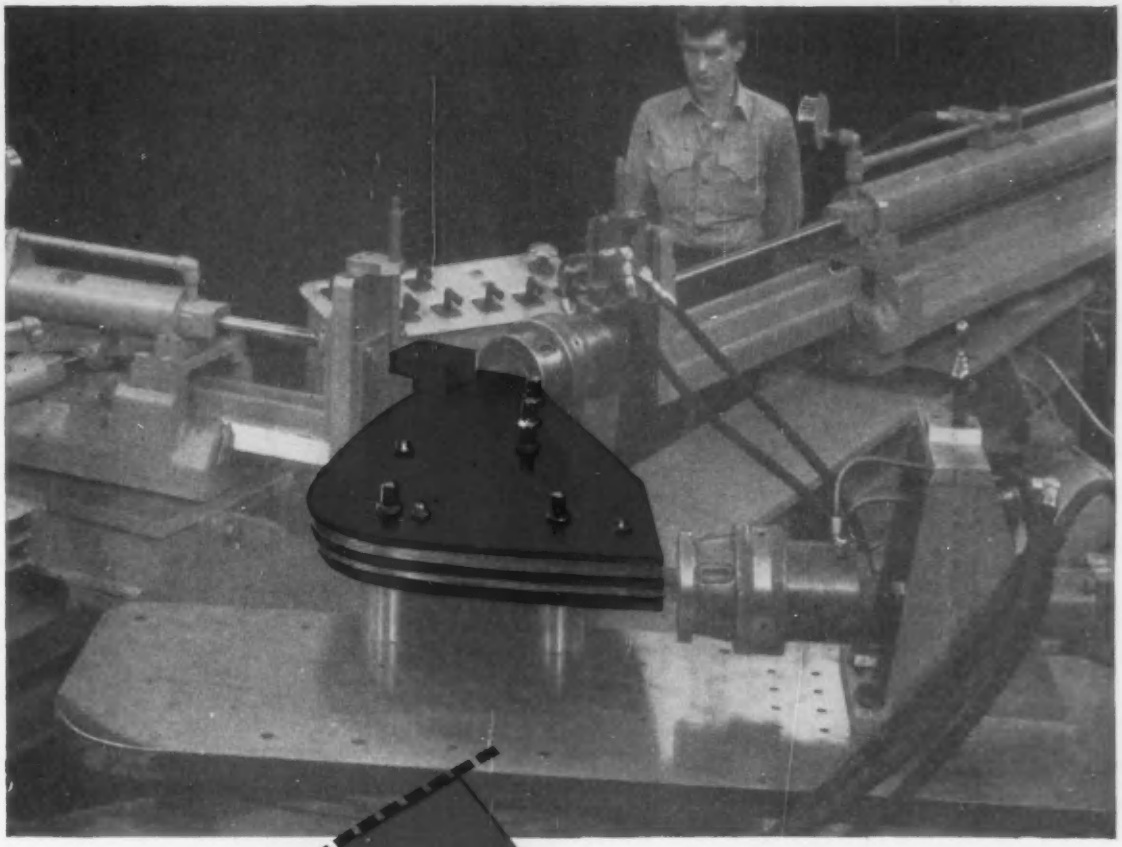
● We're ready to serve your needs with hot extrusions in any grade of stainless or high temperature steel, many tool steel grades and other steels. Call us in to help. ***Allegheny Ludlum Steel Corporation, Oliver Building., Pittsburgh 22, Pennsylvania.***

Leading Producer-High Alloy Steels

Allegheny Ludlum

WAD 8316

AL® TIME-TESTED STAINLESS STEEL



FORMICA S-52
for better stretch forming

S-52 is widely used for tooling, gauging, templates, stretch forming, forming dies and hydro-press forms.

It's smooth, slick as glass. Forms non-ferrous metals, plastics, wood, rubber, vulcanized fibres and similar ductile material. Won't transfer any surface irregularities.

S-52 is 8 times stronger than hard maple in dent resistance. Yet it's easy to machine with conventional metalworking tools.

Now available in sheet thicknesses up to 3″; widths 24″, 30″, 36″; lengths 42″, 60″, 72″, 84″, 96″. Sheets 36″ x 96″ in stock for prompt shipment. For further information on how you can use S-52 for better, more economical metal forming, write today for free bulletin 604 and S-52 data sheet. Formica Corporation, 4676 Spring Grove Ave., Cincinnati 32, Ohio. F1-1183

FORMICA

1st choice in laminated plastics

- Application engineering
- Research
- Fabricating
- Customer stock service

NOW ...The Aerosol Lubricator
MACHINE TOOL DESIGNERS
Have been asking for
Norgren
MICRO-FOG® 33AG-4

COMPACT
This new unit measures 6-1/32" x 5-3/16" x 6-1/32".

COMPLETE
Includes an Air Line Filter, a relieving type Air Pressure Regulator, and a MICRO-FOG Lubricator with a large, ½ pint oil capacity.

ATTRACTIVE
Blends in with smooth flowing design lines . . adds to the appearance of a machine tool.

EASY TO INSTALL
Offers in-line pipe connections—optional locations of air inlet and filter drain. Has two outlets for filtered air—one for MICRO-FOG.

EASY TO MAINTAIN
No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

Model 33AG-4
Lubro-Control Unit
• Filter
• Regulator
• Lubricator

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BROCHURE 556.

MICRO-FOG® by C.A. Norgren CO.
3428 SO. ELATI ST., ENGLEWOOD, COLORADO

fasteners withstand temperatures ranging from −70 to above 250 F. Nylok Corp., 611 Industrial Ave., Paramus, N. J.

For more information—
Circle 67, inside back cover

Compression-Type Pipe Coupling

This steel compression-type coupling eliminates thread cutting of steel pipe. To make a joint, the coupling is slipped over the unthreaded ends of the steel pipe and tightened with an ordinary pipe wrench. Close tolerance pipe measurements are said to be unnecessary.

The device allows misaligned pipe a maximum 7 deg of angular deflection. The coupling withstands working pressures up to 2000 psi and is UL-approved for carrying hazardous fluids. Guardian Products Corp., 1215 E. Second St., Michigan City, Ind.

For more information—
Circle 68, inside back cover

Time Delay Relay

For time delay applications requiring frequent time adjustments a line of dial head time delay relays are color-coded to identify the timing range. There are four timing ranges available, 1/10 to 3 sec, 1/10 to 10 sec, 10 sec to 2 min, 30 sec to 15 min.

The relay consists of a pneumatic timing head, a solenoid assembly, a switch, a coil and terminals. They are relatively unaffected from −65 F to 160 F. They can be supplied for con-

(Continued on page 285)

tinuous a-c duty and for continuous or intermittent d-c service. They are available for a-c operation at all standard voltages from 6 to 550 v, 50 and 25 cps. For d-c operation, they are made for all standard voltages from 6 to 230 v. A'G'A Division, Elastic Stop Nut Corporation of America, Elizabeth, N. J.

For more information—
Circle 69, inside back cover

Large Nuts

Nuts of the standard, locking and slotted types are made in sizes 2 in. and over and are carried in stock. Both low and high carbon steels are used, heat treated if desired. Security Locknut Corp., 1800 N. 15 St., Melrose Park, Ill.

For more information—
Circle 70, inside back cover

Solder Preforms

Preformed solders such as washers, rings, coils, cut shapes, pellets and foil are available in energized rosin-filled, acid-cored, single core, solid wire and sheet solder. Alpha Metals, Inc., 56 Water St., Jersey City, N. J.

For more information—
Circle 71, inside back cover

Oil and Heat-Resistant Label

This smooth-surface label resists attack from heat, oil, grease, dirt and many chemicals and acids. Under con-

(Continued on page 288)

NEW ... All the Advantages of Norgren MICRO-FOG®
in a compact, cabinet Lubro-Control Unit

... FOR AIR OPERATED MACHINE TOOL COMPONENTS
• FEED MECHANISMS
• CHUCKS
• CLUTCHES
• BRAKES

FILTER REMOVES SOLIDS, LIQUIDS,
from compressed air. Choice of 64 or 25 micron filter element. Optional location of drain.

EXACT CONTROL OF AIR PRESSURE
by relieving type air pressure regulator. 150 psi. max. primary pressure —adjustable range 0-125 psi

EFFICIENT, MICRO-FOG LUBRICATION
Creates finely-divided oil fog that can be uniformly distributed to multiple lubrication points. Operating range at 80 psi. is 4 to 85 cfm.

VISIBLE OIL FEED
makes possible adjustment of proper rate of oil flow. Positive proof of operation. Rate of feed accurately controlled by auxiliary air circuit.

Model 33AG-4
Lubro-Control Unit
• Filter
• Regulator
• Lubricator

EASY-TO-SEE OIL LEVEL
shows at a glance when oil replenishing is necessary. Easy to fill large ¼ pint oil reservoir

QUICK MAINTENANCE
No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BROCHURE 556.

MICRO-FOG® by C. A. Norgren CO.
3428 SO. ELATI STREET, ENGLEWOOD, COLORADO

Dempster-Dumpster—a truck-mounted fork lift designed to handle trash and other bulk materials, shown in dumping position. INSET: "Dacron" is the reinforcement in the V-belts on the 13-inch, 2-groove drive—increasing delivered horsepower, efficiency of hydraulic pump.

How the Dempster-Dumpster's V-belt drive efficiency was increased by premium V-belts reinforced with DACRON

REG. U.S. PAT. OFF.

The lifting and steering power of the Dempster-Dumpster generates from a single hydraulic pump driven by V-belts. To insure dependable, slip-free operation and positive starting at this important spot, Dempster Brothers, Inc., switched to premium V-belts reinforced with Du Pont "Dacron"* polyester fiber. During the six years since the change, the belts have been proving their superiority on hundreds of Dempster-Dumpsters in use throughout the country.

Slippage and stretching have been sharply reduced by the 40% greater strength of belts made with Du Pont "Dacron". Two premium V-belts now do the work formerly handled by three standard belts. The belts remain stable . . . deliver more horsepower from the pump. And the ability of these belts to withstand greater shock loading assures fewer replacements, more efficient, trouble-free operation.

In designing *your* next drive, investigate the advantages of premium V-belts made with "Dacron". They combine the unique properties of the "Dacron" yarn made by Du Pont and the highest skills of the leading V-belt manufacturers. For a list of manufacturers using "Dacron" in premium V-belts, write to E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., Wilmington 98, Delaware. Premium V-belts shown in above photo were manufactured by the U. S. Rubber Company.

6 REASONS FOR USING PREMIUM V-BELTS REINFORCED WITH "DACRON"

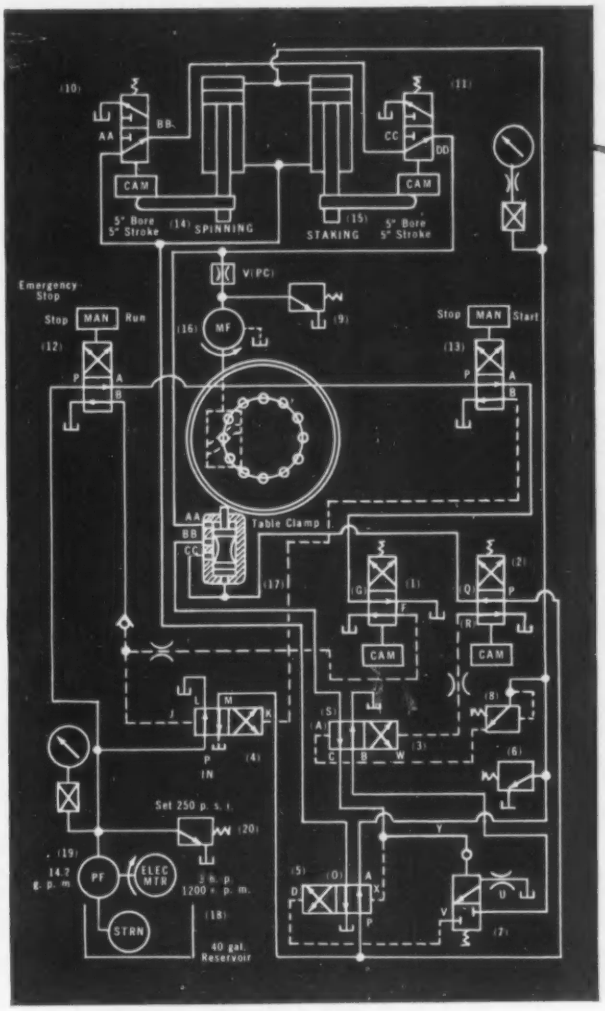
- Transmit up to 40% more horsepower.
- Withstand greater shock loading.
- Longer flex life.
- Cut downtime.
- Low stretch.
- Require less maintenance.

"Dacron" in V-Belts DU PONT

REG. U. S. PAT. OFF.

"Dacron" is Du Pont's registered trademark for its polyester fiber.

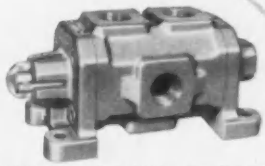
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



Write for FREE copy of "Circuit Rider" booklet. It explains the above circuit plus many others.

from the simplest to the most complex

specify... **Logan**



HYDRAULIC CONTROL VALVE

ROTOCAST HYDRAULIC CYLINDER

PRESSURE RELIEF VALVE

HYDRAULIC POWER UNIT

Yes, from the simplest to the most complex circuit and for dependable well-designed equipment . . . it's Logan. Your *"Single-Source"* supplier of air and hydraulic equipment. Eliminate multiple-source buying. With Logan you get . . . *ONE-SOURCE* manufacturing . . . *ONE-MANUFACTURER* responsibility . . . *ONE-ORDER* purchasing.

YOUR DEPENDABLE "SINGLE SOURCE" FOR AIR OR HYDRAULIC EQUIPMENT

SAVES TIME — Logan — AIR AND HYDRAULIC EQUIPMENT — EFFORT-MOTION

MEMBER: Natl. Mach. Tool Builders' Assn., Natl. Fluid Power Assn.

Logan

Properly Designed . . Properly Equipped By Logan

LOGANSPORT MACHINE CO., INC.
812 CENTER AVENUE, LOGANSPORT, INDIANA

Please Send Copy of Catalog:

- ☐ 100-1 Air Cylinders
- ☐ 100-2 Mill-Type Air Cylinders
- ☐ 100-3 Air-Draulic Cylinders
- ☐ 100-4 Air Valves
- ☐ 100-5 Logansquare Cylinders
- ☐ 100-5-1 Ultramation Cylinders
- ☐ 51 Presses
- ☐ Facts of Life
- ☐ 62 Sure-Flow Pumps
- ☐ 300-1 Hyd. Power Units
- ☐ 200-2 Rotocast Hyd. Cylinders
- ☐ 200-3 750 Series Hyd. Cyls.
- ☐ 200-4 Hyd. Valves
- ☐ 200-5 Fittings
- ☐ 70-1 Chucks
- ☐ ABC Booklet
- ☐ Circuit Rider

TO:

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

by Parker

In Automation . . . Instrumentation . . . Supersonic Aircraft—wherever true automatic control is needed, 3 dimensional cams by Parker can literally make machinery "think". By controlling relative motions through geometric and non-geometric curves, these mechanical "brains" take virtually any two variables and extract the correct functional resultant in a split second. Parker machines ultra precision into thousands of specified cam stations *and to all intermediate points between stations!* For prototype, master or production runs of 3 dimensional cams—you devise the problem, Parker will engineer and machine the answer!

Send today for "3 Dimensional Cams"—technical data on Parker's ability to make superhuman functions automatic.

THE PARKER STAMP WORKS, INC.
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

by Parker

ditions of absolute bonding, the label surfaces are reportedly hard and smooth, while continued exposure resulted in gradual darkening from light beige at 200 F to brown at 400 F. Labels which had been tinted with silver or black inks were not affected visibly. Avery Adhesive Label Corp., Monrovia, Calif.

For more information—
Circle 72, inside back cover

Device Cleans Reciprocating Mechanisms

A 360 deg, non-clogging metallic wiper-scraper for stripping of foreign matter from rods in reciprocating mechanisms consists of a scraper ring, formed from drawn beryllium copper rectangular wire. Spiral winding of the scraper ring eliminates any gap through which dirt might pass. It is held within an injection moulded elastomer element, annular in shape.

The device is currently available in all popular sizes. Equi-Flex Products Div., Master Pneumatic, Inc., 20430 Sherwood, Detroit 34, Mich.

For more information—
Circle 73, inside back cover

Pushbutton Switch

This dust, oil and water-tight unit meets all JIC and NMTBA specifications. Built to mount in 1$\frac{3}{32}$ in. dia holes on standard panel mounting centers, the switch will accommodate panel thicknesses of $\frac{1}{16}$ to $\frac{1}{4}$ in. in increments of $\frac{1}{32}$ in. Single and double-pole contact blocks can be used interchangeably with the several different types of pushbutton and selector operator heads made by this manufacturer. Interchangeable collars

(Continued on page 292)

"Little things" will mean big problems on the production line, too!

ELGIN **can mass produce your miniaturized assemblies at lower cost**

As more companies plan for miniaturized production they encounter the problem of handling small parts efficiently. Many leading producers solve this difficulty by letting Elgin "thread the needle" for them. Elgin has the broad experience and specialized facilities to produce small assemblies in volume at lower cost. After all, miniaturization has been our business for years.

Read about Elgin's "Practical Miniaturization." Our booklet tells how Elgin has helped others . . . how Elgin can help you. Write today for your copy.

ELGIN NATIONAL WATCH COMPANY

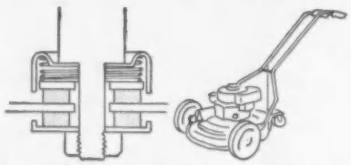
MICRONICS DIVISION • ELGIN, ILLINOIS

TAYLOR Laminated Plastics Vulcanized Fibre *Shop Talk*

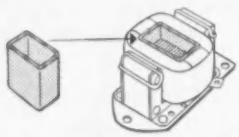
TAYLOR FIBRE CO.
Plants in Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

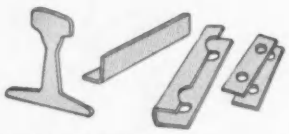
Tips for designers



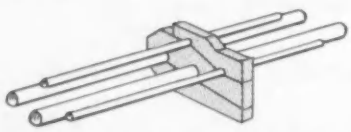
Rotary lawn mower utilizes abrasion resistance of Taylor phenol laminate washer in slip-clutch attachment of drive shaft to cutting blade.



Coil forms for this solenoid have to operate at high temperatures . . . an ideal application for Taylor glass melamine laminates.



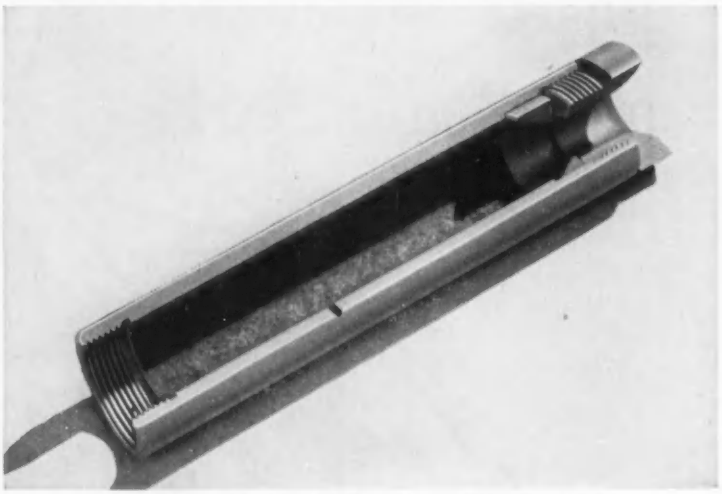
Railroad track-joint insulation, a specially developed grade of Taylor vulcanized fibre, withstands heavy impact and mechanical stress of high-speed trains.



Fuel-line clamp for a fighter plane's "pipeline" system is machined from Taylor fabric base laminate which has high mechanical strength and resists extreme temperature and humidity.

NEW TAYLOR
COPPER-CLAD LAMINATES

Taylor GEC (glass-epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenol) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



Fuse holder used in power lines for underground trolley service is machined to extremely close tolerances from Taylor Grade XX tubing.

Make strong insulated parts

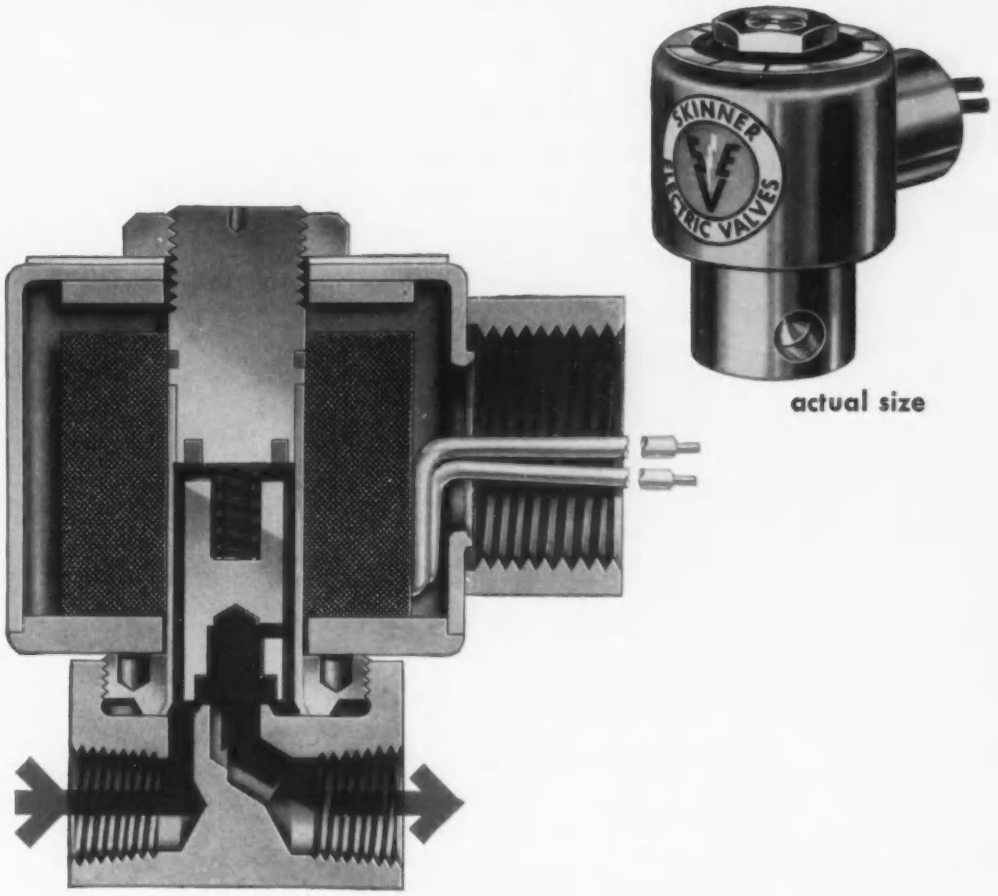
. . . from TAYLOR *laminated tubes and rods*

These rugged, readily machined materials make outstanding electrical or mechanical components—at substantial savings in fabrication, assembly, and material costs. Taylor Laminated tubes and rods are the logical choice wherever specifications call for mechanical strength, heat resistance, and electrical insulation.

Taylor tubes and rods are made in many paper, fabric, and glass-base grades, with special formulations of phenol, silicone, melamine, or epoxy resins. Within the complete line the designer and the production man can find a variety of combinations of electrical and physical properties for a broad range of product applications.

Taylor tubes and rods are standard products. Tubes are available with inside diameters as small as three thirty-seconds of an inch . . . rods with diameters from one-sixteenth of an inch.

A Taylor sales engineer will be glad to help you select the grade and size of laminated tubes or rods to match the exact requirements of your application. And, you can eliminate many purchasing, stocking and manufacturing problems by having the Taylor Fabrication Division produce finished parts to your specifications. Call your nearest Taylor sales engineer for a discussion of your specific needs.



actual size

New C-series solenoid valve offers recognized "Skinner Quality" at low cost

This is a faithful reproduction – in miniature – of the time-tested, 2-way, normally closed Skinner V5 except that the body is made of brass.

This new, compact Skinner valve weighs only 12 ounces, yet it's rugged enough to last millions of cycles on most applications. It is a packless, direct-acting valve with only two moving parts. And it's absolutely bubbletight – even on vacuum. This C-Series Skinner valve is failproof, too – positive closing is assured by a spring return. It can be mounted in any position and is ideal for direct-line mounting.

You'll find this new valve, with its recognized "Skinner Quality," the perfect low-cost answer to a wide range of flow control problems. It works efficiently with air, water, oils, gasoline and many other media. Typical applications include: automotive fuel systems, welding equipment, vending machines, lubricating devices, spraying equipment, air horns, water softeners, humidifiers and instrumentation.

Our Bulletin D11.1 contains complete information on this valve – flow curves, optional features, dimensions, electrical data, etc. We will be happy to send you a copy on request.

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
THE SKINNER CHUCK COMPANY

THE RIGHT ANSWER

for greater productivity from machinery investments

Sterling Speed-Trol Variable Speed Motors

Sterling Slo-Speed Gear Motors

Sterling Constant Normal Speed Motors

Sterling Multi-Mount Speed Reducers

Sterling

ELECTRIC POWER DRIVES

The important distinguishing features of Sterling Electric Power Drives can bring greater productivity and cost reductions to your manufacturing operations. To help you meet the competitive challenge of mechanization and automation, Sterling offers you a three-fold answer: Power transmission equipment, variable speed or constant speed—manual or automatic controls—and an application engineering service. Together, these give your machinery the type of drive systems that will achieve maximum productivity at lowest cost.

Write today for Bulletin No. 185. Discover the big advantages Sterling Electric Power Drives can bring to your plant.

STERLING ELECTRIC MOTORS

Los Angeles 22 • Chicago 39 • Cincinnati 37 • New York 51

are supplied in three different heights to enable changing from a flush to extended type button by the simple expedient of merely changing the collar. Buttons are available in an assortment of colors to conform with standard codes and are made of a nonfading glass-filled polyester resin. National Acme Co., 170 E. 131 St., Cleveland 8, Ohio.

For more information—
Circle 74, inside back cover

Copper Dispersion for Non-Conductors

A colloidal dispersion of metallic copper in a lacquer solution is said to provide a conductive surface coating. The dispersion is suggested for printed circuitry and electroplating of nonconductors and is reportedly cheaper than other coatings such as silver paint or copper foil. Acheson Colloids Co., Port Huron, Mich.

For more information—
Circle 75, inside back cover

Expanded Polyethylene Foam

Offered in such semi-finished molded components as rings, blocks, rods and sheet, the material may be used for heat and electrical insulation, sound proofing applications.

Unlike branch polyethylene whose specific gravity is 0.92, expanded polyethylene has a specific gravity of 0.46, or where required, 0.33. The material is unicellular, and has a tensile strength of 500 to 600 psi. American Agile Corp., P.O. Box 168, Bedford, Ohio.

For more information—
Circle 76, inside back cover

Hydraulic Traverse and Feed Controls

For the oil-hydraulic systems in machine tool and production equipment, these controls have valve sections for direction and feed control. They are designed for use with ¾ in. nominal pipe size. Maximum recommended operating pressure is 1000 psi.

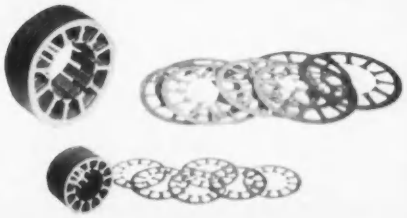
Series CPP traverse and feed pan-

(Continued on page 296)

Araldite®
First in Epoxies

Precision...Large Scale!
Araldite Epoxy Resins adapt themselves to large scale precision design as illustrated in this 14 foot aluminum reflector. The skin, made with Araldite and glass cloth, is then bonded with Araldite Epoxy to aluminum and honeycomb to complete the structure.
Formulator: Emerson & Cuming, Inc.
Customer: I.T.E. Circuit Breaker Co.

Precision...In Miniature!
High bond strength and excellent electrical properties of Araldite Epoxy Resins make possible the design and production of this chatter-less stator.
Formulator: Rubber & Asbestos Corp.
Customer: Kollsman Instrument Company.



Whether your use of Araldite Epoxy Resins would be for coating, tooling, electrical, adhesive or laminating applications, formulations based on Araldite Epoxy Resins can meet your requirements exactly. The excellent adhesive, mechanical and chemical properties of Araldite Epoxy Resins, plus their versatility, make them "a natural" to promote design improvements and save time and money on the production line. Here are two of the many instances where Araldite Epoxy formulations provided the right answer to large and small scale design problems.

The Technical Services of Ciba's Plastics Division are the finest in their field. For full information on how Ciba Araldite Epoxies lead to product development and production improvements, write...

Ciba Araldite Epoxy Resins come with the assurance that they have met not only our rigid PRODUCTION qualfiy control standards but the specific APPLICATIONAL requirements of the user as well.

Ciba produces basic resins only, to be formulated for intermediate and end uses.

C I B A

PE-11

CIBA COMPANY INC., Plastics Division
Kimberton, Pennsylvania

Please send me full information on CIBA Epoxy Resins for

☐ Tooling ☐ Structural Laminates ☐ Surface Coatings
☐ Electrical ☐ Hi-Strength Adhesives ☐ Plastic Body Solders

NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

CITY_____ STATE_____

when should you pay $13.00* a pound for TITANIUM?

The answer is *when its cost/life ratio makes titanium less costly than other metals*—as it often does. Look at it this way . . .

More Metal Per Pound—Titanium weighs only 56% as much as steel of the same strength. Where 50 pounds of steel is needed—28 pounds of titanium will do the job.

It's Final Cost That Counts—Fabricating takes the lion's share of production costs on most jobs. Considering material and fabricating costs together usually whittles down the titanium price differential to 2 or 3 to 1. And, most important . . .

Titanium Outlasts Most Metals—even those generally considered 'corrosion-resistant,' by 10, 20, even 50 times or more.

Added together, these facts often make titanium the most inexpensive material you can use. And only titanium can provide its exceptional combination of *light-weight, high-strength,* and *resistance to corrosion.* Ask a REM-CRU engineer to give you complete details about what titanium can do for you.

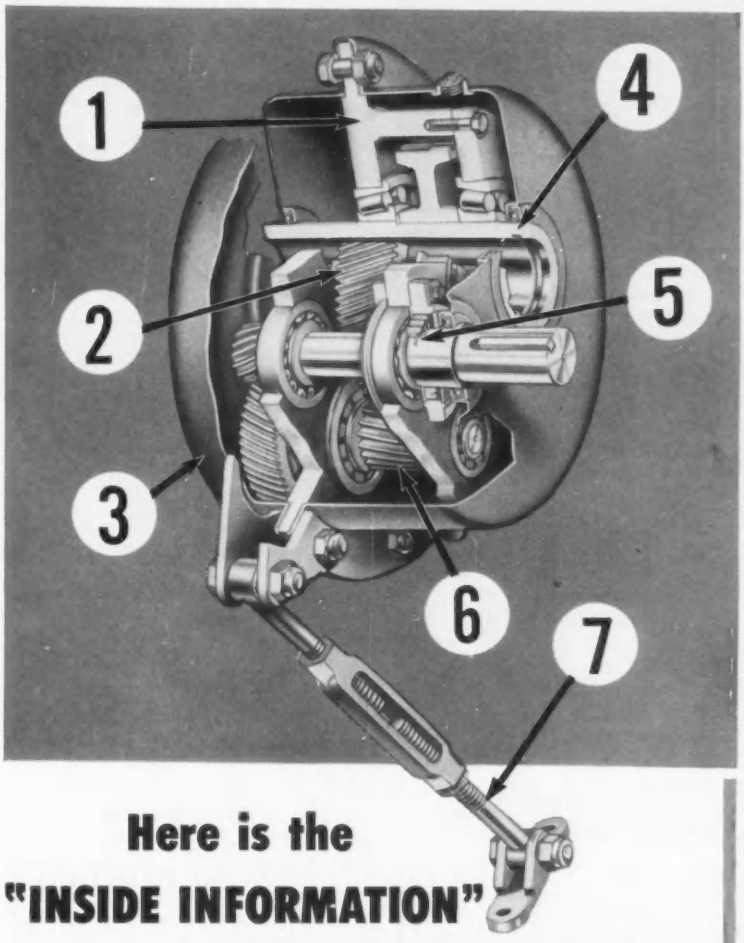
**The actual cost of titanium mill products varies with the grade, size and quantity ordered. The $13.00 figure is representative of today's prices for items used in commercial applications.*

To keep abreast of the latest developments on this vital metal, write to Dept. P-11 for the Rem-Cru Review—a free periodical presenting the latest technical data on titanium alloys.

REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

Sales Offices: 3338 South Malt Avenue, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y.



Here is the "INSIDE INFORMATION" on FALK ALL-STEEL Shaft Mounted Drives

Take a careful look inside the Falk all-steel Shaft Mounted Drive, and you will know why this newest member of the famous Falk family is ideal for applications where direct mounting on the driven shaft is desirable. It is the only drive in its field with all these superior "In-built" factors:—

1 **All-steel Frame,** with more than double the rigidity of iron, supports all rotating elements.

2 **Precision Helical Gears,** designed and machined by Falk, rated to AGMA standards.

3 **Pressed Steel Housings,** whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.

4 **Through Hollow Shaft** with counter bore provides for easiest installation or removal from driven machine shaft extensions.

5 **Backstop** can be furnished with the unit or added later for positive prevention of reverse rotation.

6 **Positive Lubrication,** continuous direct dip of revolving elements at all speeds.

7 **Tie Rod** and turnbuckle serve as anchor and facilitate V-belt or chain adjustment.

Write to Department 247 for engineering bulletin, including selection and dimension details.

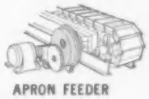
EFFICIENT SPEED REDUCTION IN LIMITED SPACE

SIX SIZES

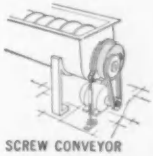
- 1/2 to 30 hp
- Single or double reduction
- Wide output speed range—420 to 10 rpm

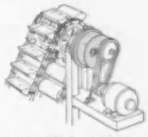
Expressly designed for topflight performance on installations requiring considerable speed reduction in limited space, the all-steel FALK Shaft Mounted Drive has quickly won acceptance throughout industry. This sturdy, compact, versatile reducing unit is an ingenious variation of the highly successful FALK Motoreducer design, pacemaker in its field for more than 20 years. Here, the time-proved design is adapted for mounting directly on the shaft to be driven, using V-belt connection to motor. Investigate now!

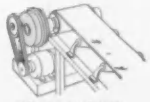
A FEW TYPICAL APPLICATIONS

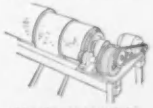

APRON FEEDER

LINE SHAFTING


SCREW CONVEYOR


BUCKET ELEVATOR


BELT CONVEYOR


GRAVEL CLASSIFIER

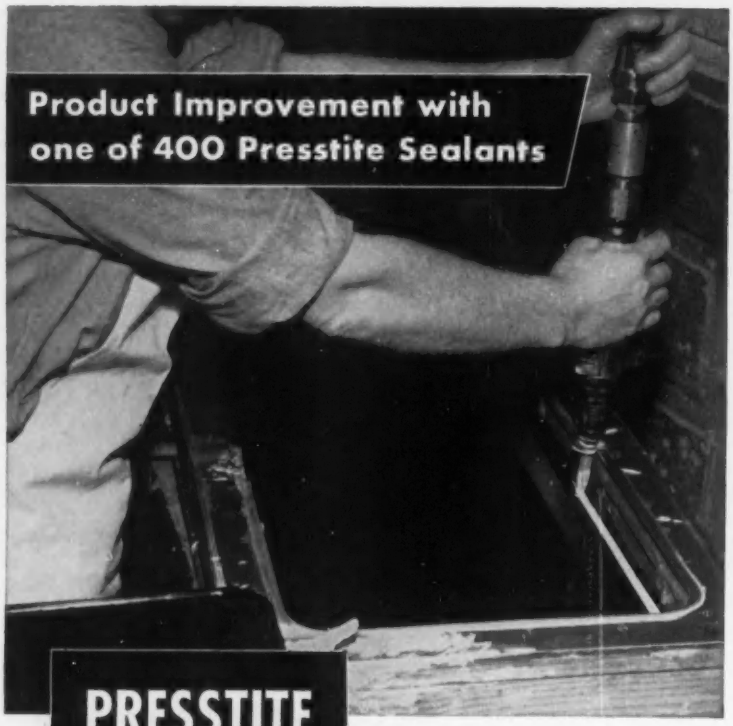
THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry



PRESSTITE *Plastisol Sealers* are TOUGH COHESIVE ELASTIC

Excellent Seal Against *Water, Moisture, Dust*

These modern sealants consist of 100% solid materials. When subjected to proper heat, they cure to a tough elastic body, having excellent adhesion to clean metal surfaces. They are free from contaminating odors.

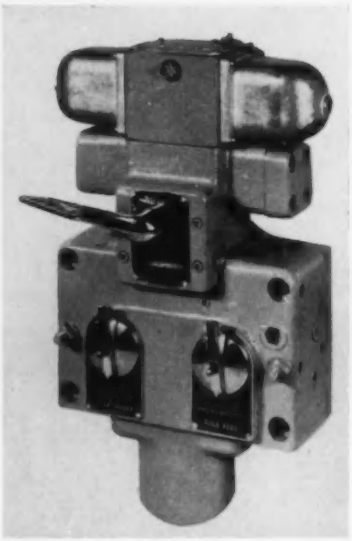
Other characteristics:

- *In pumpable form* from thick to thin consistencies. Tan, green-yellow, off-white colors.
- *Resistant* to alcohols, aliphatic hydrocarbons, oils, dilute acids (milk), alkalies. Highly resistant to water and moisture vapor.
- *Highly stable,* non-staining.

DESCRIBE YOUR NEEDS... for free working sample best suited to your job.

PRESSTITE SEALING COMPOUNDS
PRESSTITE-KEYSTONE ENGINEERING PRODUCTS COMPANY
K A P

A Division of AMERICAN-MARIETTA COMPANY
3750 CHOUTEAU AVENUE, ST. LOUIS 10, MISSOURI



els consist of the redesigned flow control valve section in combination with a version of the DG4 solenoid-operated directional valve. Models in this series can be used to control fully automatic machining operations. Standard solenoids are for 115 v, 60 cps, a-c service. Approximate panel weight is 88 lb.

Series CPD models consist of the flow control valve section combined with solenoids. These units are also applicable to fully automatic operations, but include a manual operating lever for set-up and emergency use. Standard solenoids are for 115 v, 60 cps, a-c service. Approximate panel weight is 98 lb.

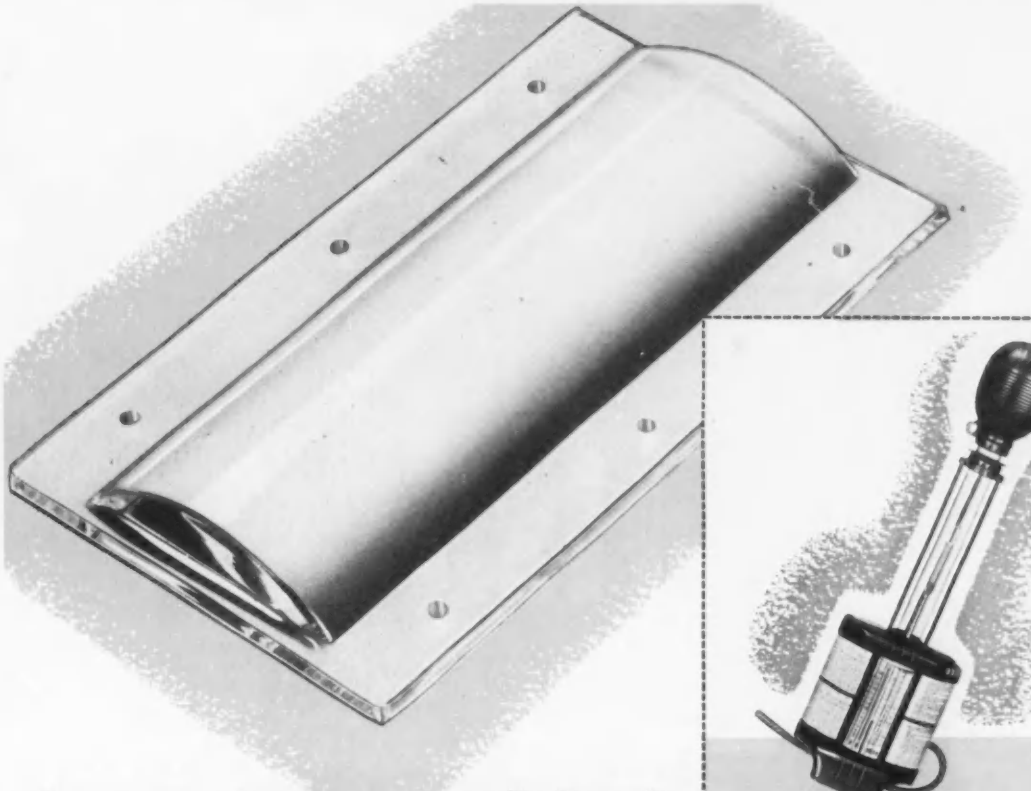
Series CPN panels consist of the redesigned flow control valve section with a manual operating lever. These units are designed for use with an external solenoid to actuate motion reversal. Approximate panel weight is 65 lb. Vickers Inc., Box 302, Detroit 32, Mich.

For more information—
Circle 77, inside back cover

Plug Valve

In the closed position, one O-ring contained on the surface of the plug (90 deg from the flow passage through the plug) serves as a flow seal. This sealing ring surrounds the inlet port and is said to provide dead-tight shut-off. In the open position, the valve is full ported and allows a straight-

(Continued on page 300)



A custom molded product of Sylvania's 4-way service

High quality custom molding to meet critical parts problems, such as the "magic eye", is an important part of Sylvania's *four-way* service to designers.

Sylvania's Parts Division also offers you complete facilities for metal parts ranging from wire forms to deep drawn eyelets; plated and clad specialty wires; and special components.

For the complete story, write for the Portfolio of 4-way Service to Designers.

Plexiglass Magnifier Lens calls for close tolerances

Key feature in new anti-freeze tester made by E. Edelmann & Co. is the "magic eye" magnifier lens which provides easy readings under all lighting and weather conditions.

It took a qualified molder though, to maintain the high level of quality dictated by this part's function. It had to be kept free from bubbles and blemishes. Mounting hole tolerances were held to ±.003. Flat surface was controlled to within .010 T.I.R. and the part was annealed to insure flatness over an extended shelf life.

The "magic eye" was molded of Rohm & Hass methyl methacrylate on a 12-oz. Reed-Prentice press.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS · 4-way service from one source

How **DENISON** hydraulic power works for Adamson United

Precision control for a metal monster

Denison variable volume axial piston type pump with pressure compensating control, key to this hydraulic system for Adamson United Press.

● To Denison Engineering went the task of designing accurate, foolproof control equipment for this huge compacting press built by Adamson United, Akron, Ohio. Covering more than 40 square feet of platen area, the press has a 40-inch ram designed to operate on a 2300 psi hydraulic system.

The control system developed by Denison employs a variable-volume axial-piston pump driven by a 15 h.p. motor. A manifold-type hydraulic panel completes the system.

Engineering consulting service like this is available to you at all times to save your design time and assure dependable, efficient performance of your hydraulic circuits. Write us. Denison Engineering Division, American Brake Shoe Co., 1194 Dublin Road, Columbus 16, Ohio.

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON HydrOILics

Sharonart is BIG NEWS!

TO CHANGE THE *Style*

CHANGE THE STEEL

SWITCH TO *Sharonart*

To designers who haven't already investigated Sharonart*, this page should be "good news."

Here's a steel made to order for imaginative product designers. Steel with decorative patterns pressed into the surface that enhance the appearance of any product. Sharonart* gives an exceptionally fine surface for two-tone painting.

Designers can select from dozens of patterns or make up their own repetitive design which will be reproduced in the surface of the steel. They can choose from almost any type of steel, including stainless.

Hundreds of manufacturers — from cabinet hardware to automobiles—have switched to Sharonart* because it enables them to *change the style by simply changing the steel.*

Get the full story. Ask your Sharon salesman or write direct for the new Sharonart* booklet.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

Trademark registered by Sharon Steel Corporation

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CINCINNATI
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TORONTO, ONT.

SHARONSTEEL

SHARON STEEL CORPORATION PE-11-56
Sharon, Pennsylvania

Please send Sharonart Surface Rolled Patterns in Steel brochure ☐ Galvanite booklet ☐
Sharon 430 Stainless Steel Folder ☐

Name_____

Position_____

Company_____

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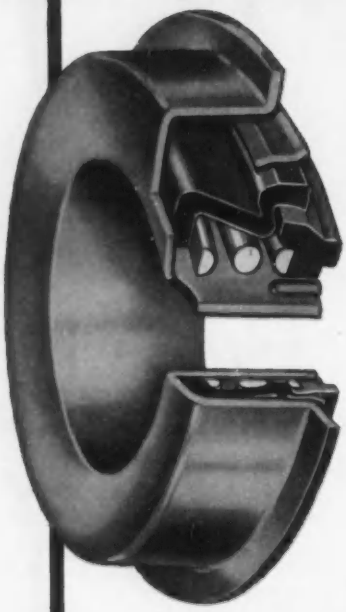
YOU ASSURE...



✓ Greater Economy
✓ Better Performance
WITH
JOHN CRANE
SELF-ALIGNING
TYPE 11-A
Rotary Shaft
SEALS

BECAUSE:

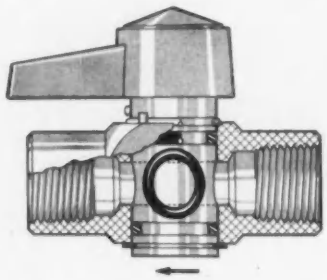
1. **You save on production time.** The Type 11-A Seal is a low cost, compact, factory assembled unit. Its "pressed-in" cartridge-type construction makes for quick installation as equipment rolls by.
2. **One seal size fits several shaft diameters.** Retainer is so constructed that it does not contact the shaft, eliminating the need to "switch" seals when shaft specifications vary slightly.
3. **Damaging stresses are eliminated.** Since the entire unit remains stationary, the seal readily lends itself to applications involving high speed and vibration.
4. **Safeguarded against corrosion.** Metal spring utilized to maintain constant contact of sealing faces is fully enclosed in synthetic rubber bellows. This eliminates the need for costly corrosion-resistant spring materials.

"John Crane" Type 11-A Seals are recommended for temperatures to 212°F., pressures to 20 psi. Available in four stock sizes from ⅛" to ¾".

Contact "John Crane" engineers on your requirements today. Request illustrated catalog on complete line of seals for all services.

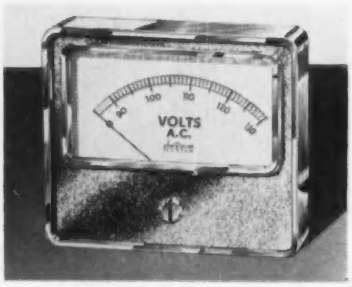
Crane Packing Co., 6445 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd. Hamilton, Ont.*

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS



through flow passage. Static O-rings at the top and bottom of the plug and around its circumference are used to prevent stem leakage. The valve is made of brass and is available with ¼ in. female pipe connections. Circle Seal Products Co., Inc., 2181 E. Foothill Blvd., Pasadena 8, Calif.

For more information—
Circle 78, inside back cover



Expanded Scale Voltmeters

These expanded scale voltmeters can be either a-c or d-c. With expanded scale, 90 to 130 v, a-c rms, the device was designed for line voltage measurements and is available in nine case styles. Phaostron Instrument and Electronic Co., 151 Pasadena Ave., S. Pasadena, Calif.

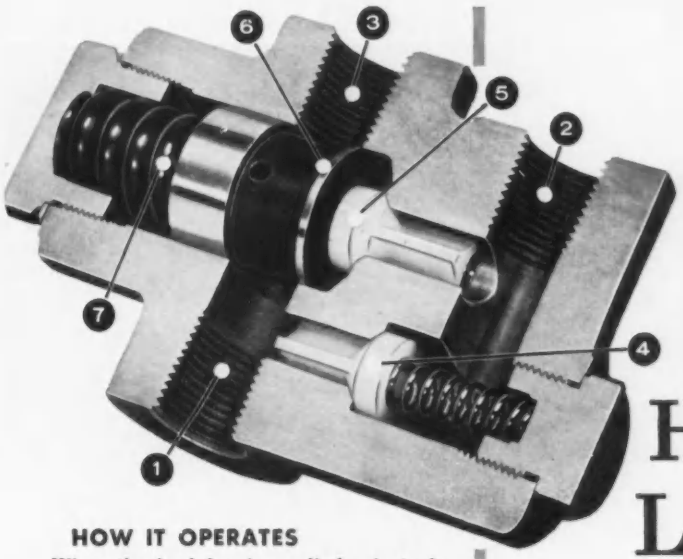
For more information—
Circle 79, inside back cover

Machine Tool Relay

A six-pole, in-line, 10 amp relay (NEMA Type A1B) designed for applications such as machine tools and control panels has a saddle-type terminal which permits wiring from four directions, with either plain wire or crimped-on terminal connections. The relay is available in both standard and latched-in forms.

The relay is available in two, three, four and six-pole models and in all

(Continued on page 304)



NEW Webster Hydraulic Lock Valve

PROVIDES POSITIVE LOCK OF LOADED HYDRAULIC CYLINDERS UNTIL FLOW IS DELIBERATELY REVERSED . . . PREVENTS GRADUAL DROPPING

• WEBSTER'S new Model WV Hydraulic Lock Valve has been designed to eliminate a common fault in many hydraulic systems—the gradual dropping of loaded cylinders due to seepage of fluid around the spool of a standard hydraulic directional valve.

This new lock valve is particularly important on equipment like road building machinery, agricultural equipment, materials handling equipment and other lifting applications. It has a capacity of up to 20 gpm, at pressures up to 1500 psi.

HOW IT OPERATES

When the load bearing cylinder is to be raised, the directional valve is moved into the raised position and oil flows into either port **1** or **3** of the lock valve. (The port not used may be plugged or used for a pressure gauge.) Port **2** is connected to one end of the double-acting cylinder which will move the load.

The oil flowing into port **1** or **3** opens nylon check valve **4**. The spring behind this valve is very lightly loaded. The oil flows through the spool and out port **2** into the cylinder, raising the load.

When the directional valve is put into neutral position, valve **4** closes instantly, preventing the oil from returning through port **2**, and therefore locking the lifting mechanism into place. To lower the load, oil is applied to the other end of the double-acting cylinder, forcing oil back into port **2**.

In order to discharge the oil back to the directional valve through either ports **1** or **3**, it is necessary to open nylon valve **5**. This valve is held by piston **6** and the loaded spring **7**.

Loads on this spring may be varied at the factory—a typical load being 1200 psi.

The instant the valve is opened pressure is exerted against the large area of piston **6** and the pressure required to hold the valve open is reduced to below 150 psi. This design feature eliminates the necessity of applying high load during the entire lowering stroke.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE • WISCONSIN

Write today for complete information

☐ Please send us complete information on WEBSTER'S WV Lock Valve

☐ Please send catalog on complete WEBSTER line

Name_____

Title_____

Company_____

Street_____

City, Zone & State_____

MANUFACTURERS OF A COMPLETE LINE OF OIL HYDRAULIC PUMPS FROM 1/5 TO 30 GPM CAPACITY

There is NO SUBSTITUTE for a forging: NO SUBSTITUTE for Wyman-Gordon Experience

There is more to the superiority of the forged crankshaft than just strength.

No other method of fabrication can compare with the forging process for dependability. The uniformity and predictability of physical properties with minimum variance from piece to piece or from one location to another in the same piece is assured to the greatest degree by modern forging practice.

Top automotive engineers agree that the use of a forged crankshaft permits the design of a more compact engine which is a decided advantage when thinking in terms of limited space available and overall engine weight reduction.

As compression ratios increase and engine outputs go up the risk factor must be reduced. Again, the uniformity of quality in the backbone of the engine, the crankshaft, is most essential and made possible only by a forging.

There is NO SUBSTITUTE for a forging and in a forging there is NO SUBSTITUTE for WYMAN-GORDON quality and experience.

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

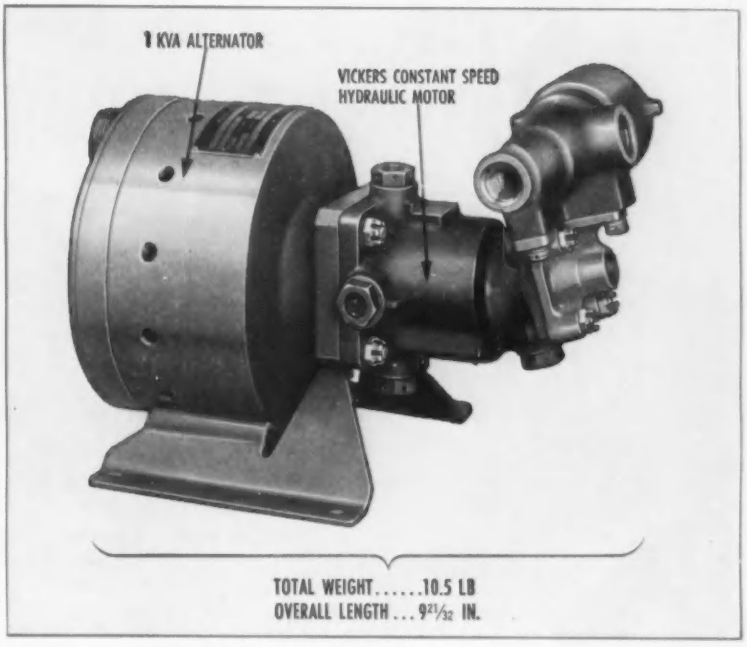
HARVEY, ILLINOIS • DETROIT, MICHIGAN

New Vickers Airborne Electrical Power Package

. . . Saves Weight and Space

Utilizes the Hydraulic System for More Efficient Production of AC Power

This new isolated electrical power package provides closely regulated AC power with minimum weight and envelope while drawing its power from a hydraulic system. In new designs or when adding electronic equipment to aircraft designs in which the electrical system is already loaded to capacity, this versatile package provides the needed AC power from flow available in the hydraulic system. This generally is permissible without system change as the full flow is seldom demanded except for a few seconds under rare circumstances. Even in such cases, full flow can be guaranteed to these hydraulic functions through the use of a simple priority valve which starves the AC power package momentarily.



Less Weight and More Efficient

Important weight savings are achieved through the use of this package instead of an inverter which may also require an increase in the DC generator and line capacities. In one instance, the 10.5 lb 1 kva package replaced a 38 lb inverter for co-pilot instrumentation. An additional advantage is that the package has 62% overall efficiency while that of the inverter was 35-40%.

Extreme altitude operation is no problem as the Vickers isolated electrical power package contains no brushes or other altitude-sensitive components.

Features of AC Generator

The permanent magnet type AC generator has excellent life and reliability. It requires no bulky voltage regulator . . . is inherently smaller and lighter than conventional generators due to the elimination of the exciter and slip rings. It also has higher overall efficiency resulting from elimination of all excitation losses. Additional advantages are that the permanent magnet is unaffected by momentary short circuit, or separation of field and armature without keeper, or by temperature cycling. It is also not susceptible to aging or shock. This unit is 120/208 volt, three phase, wye connected with 400 cps at 8000 rpm. It is capable of continuous duty under environments of 0-55,000 feet altitude and ambient temperatures from −65 F to 250 F.

Hydraulic Motor Drive

The generator is directly driven by a Vickers Constant Speed Hydraulic Motor having fixed stroke and an integral flow control valve that maintains an 8000 rpm speed setting within ±2½% regardless of the load (as long as valve inlet pressure is greater than load requirement). For the unit shown above, maximum operating pressure is 3000 psi while rated output of 1 kva requires operating pressure of 2200 psi. Special configurations will maintain 400 cps frequency within ±0.1% regardless of load. This motor has a very high horsepower-weight ratio and its overall efficiency exceeds 92%. It is a time-proved design capable of many hundreds of hours of continuous service without attention.

Many Uses and Sizes

The applications for this isolated power source are numerous. For multi-engine aircraft, its use for co-pilot instruments provides dual reliability. This package has been used to supply controlled frequency AC power in emergencies when the only source of power in the airplane is a ram air turbine driven pump. The efficiency of this arrangement minimizes the size and weight of the ram air turbine necessary to provide emergency hydraulic and electric power.

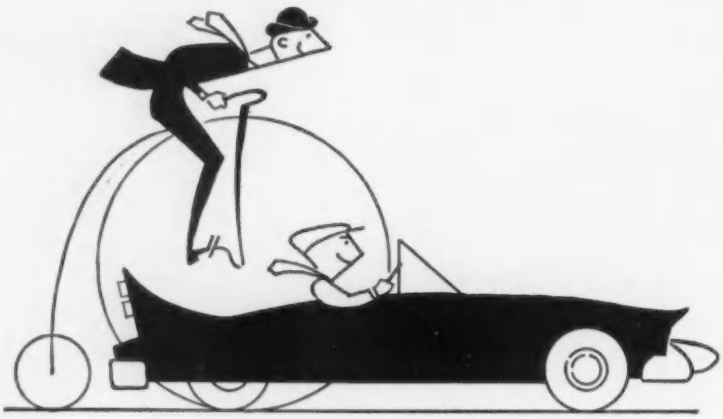
Now available in the sizes listed below, larger packages can also be supplied from existing components. Vickers is prepared to develop the package best suited to a specific need. For further information, get in touch with your nearest Vickers Aircraft Application Engineer.

Vickers Airborne Electrical Power Packages

kva output	weight, pounds
0.5	7.0
1.0	10.5
1.5	12.5
2.0	15
2.5	17
3.0	19

Larger capacities with minimum weight are available.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1454 • Detroit 32, Michigan
Aircraft Application Engineering and Service Offices: El Segundo, California, 2160 E. Imperial Highway • Detroit 32, Michigan, 1400 Oakman Blvd. (Service Only) • Arlington, Texas, P. O. Box 213 • Washington 5, D.C., 624-7 Wyatt Bldg. Additional Service facilities at: Miami Springs, Florida, 641 De Soto Drive
TELEGRAMS: Vickers WUX Detroit • TELETYPE "ROY" 1149
CABLE: Videt
OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd. Great West Road, Brentford, Middx., England
Engineers and Builders of Oil Hydraulic Equipment Since 1921



DESIGN OPPORTUNITIES AHEAD WITH WHITNEY CHAIN DRIVES

When designing or replacing power transmission or conveyor drive units, the adaptability of Whitney Chain Drives provides economical design and increased production. Whitney Chain Drives assure utmost efficiency . . . provide positive, reliable performance in all types of service from fractional to hundreds of horsepower.

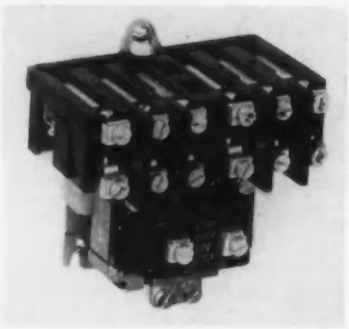
Important . . . when considering your chain source. Whitney Chain has specialized in finished steel precision chain drives since 1896 when Whitney pioneered the famous alloy steel bicycle chain. Whitney's undivided concentration on producing quality precision chain drives is backed by complete factory warehouse stocks and engineering service across the country.

Write for descriptive literature — or call your nearest Whitney Field Office for prompt and practical engineering assistance on all drive problems.

Whitney
CHAIN COMPANY

204 HAMILTON STREET, HARTFORD 2, CONNECTICUT

ROLLER CHAIN • SILENT CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS



voltages and frequencies up to 600 v, 60 cps. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 80, inside back cover

Teflon Tape

Fifteen gages of Teflon tape, from 0.002 to 0.125 in., are currently available. Tolerance on gage ranges from ±0.0005 in. on thin stock, to ±0.002 in. on thicker gages. The tape can be obtained from stock in widths ranging from ½ to 12 in. Tri-Point Mfg., Inc., 401 Grand St., Brooklyn 11, N. Y.

For more information—
Circle 81, inside back cover

Epoxy-base Paint

A paint that is said to form a gloss coating on all metals, wood, wallboard, plaster and masonry surfaces is available in black and white, plus all other colors that are consistent with chemical resistance. Sealube Co., Wakefield, Mass.

For more information—
Circle 82, inside back cover

Tin-Clad Nickel Strip

A composite metal, this material consists of pure tin solder clad on one side only to pure (Type 330) electrolytic grade nickel. Each layer of metal is of uniform thickness. The metals are bonded by a solid-phase bonding process without the use of brazing alloys or other intermediate material.

Employed principally by the transistor industry for germanium cradle supports, tin-clad nickel can be used for any tin solder application requiring

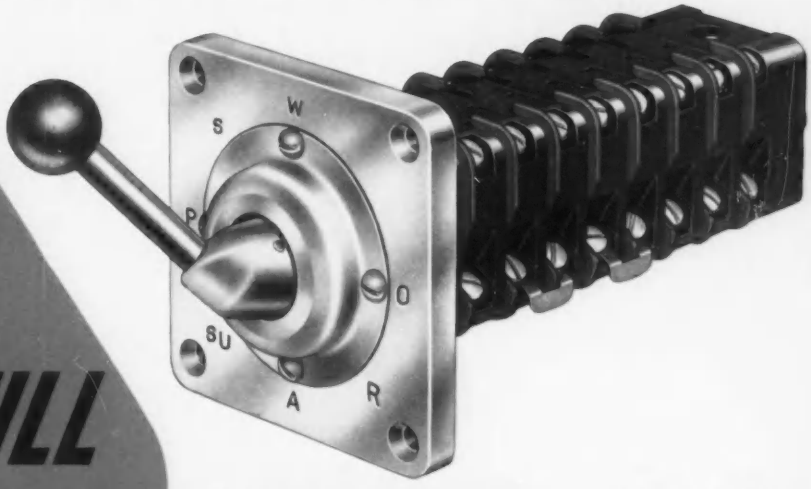
(Continued on page 307)

This is IT!

ONE POINT of CONTROL for ANY APPLICATION

with the

ARROW AH HART



PUSH-PULL SELECTOR SWITCH

SAVES APPARATUS AND SPACE . . . PROVIDES SIMPLIFIED CONTROL

COMPARE
A 2-SPEED REVERSING LATHE
8 OPERATIONS

involving spindle motor, coolant motor, brake and a "Safe" position.

CONVENTIONAL CONTROLS	AH "PPS"
6 Magnetic Units	1 Magnetic Unit
7 Push Buttons	1 "PPS" Switch
11 UNITS . . .	SAVED

COMPARE
A DRY CLEANING MACHINE
8 OPERATIONS

involving fan, pump, washing and extractor motors and "Automatic" and "Off" positions.

CONVENTIONAL CONTROLS	AH "PPS"
6 Magnetic Units	3 Magnetic Units
1 Timer	1 Timer
14 Push Buttons	1 "PPS" Switch
16 UNITS . . .	SAVED

COMPARE
AN AUTOMATIC BAKELITE PRESS
8 OPERATIONS

involving a choice of jogging for each separate function or completely automatic cycling.

CONVENTIONAL CONTROLS	AH "PPS"
6 Magnetic Units	2 Magnetic Units
1 Timer	1 Timer
9 Push Buttons	1 "PPS" Switch
12 UNITS . . .	SAVED

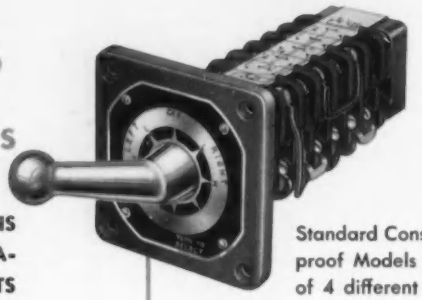
THE SIMPLE ANSWER TO YOUR COMPLEX CONTROL PROBLEMS

REDUCES CONTROLS REQUIRED • SAVES SPACE and WEIGHT • IMPROVES LAYOUT and APPEARANCE • ADDS FLEXIBILITY, VERSATILITY • PROVIDES MAXIMUM SPEED, EASE and SIMPLICITY of OPERATION • FOOLPROOF, PROTECTS OPERATOR and EQUIPMENT • ASSURES PEAK PERFORMANCE

TURN THE PAGE FOR AN ELECTRICAL DESCRIPTION and OPERATIONAL FEATURES

Control TAILORED TO YOUR EXACT NEEDS

— THE ARROW-HART "PPS" SWITCH IS CUSTOM BUILT TO YOUR SPECIFICATIONS FROM STANDARD COMPONENTS



STANDARD CONSTRUCTION WITH CAST LEVER HANDLE ILLUSTRATED

Standard Construction or Oil and Weatherproof Models are available with a choice of 4 different Handle Types.

What the "PPS" does

- **A SINGLE "PPS" UNIT PROVIDES SINGLE-POINT CONTROL . . .** involving practically any desired circuit arrangement.
- **THE "PPS" REDUCES THE NUMBER OF CONTROLS REQUIRED**
  - — because it is the ***ONLY*** pilot device required for practically all installations.
  - — because the "PPS" makes a single ***MAGNETIC*** control (starter, contactor etc.) do the work of many.

Here IS THE BASIC OPERATING PROCEDURE SIMPLE AS A-B-C

A **PUSH and TURN TO SELECT . . .** The operator must first push the handle — opening all circuits and disconnecting all controls. The handle can then be turned to any desired position; this selects the correct circuits for the required function. Any number of unwanted, intermediate functions can be passed without energizing their circuits.

B **PULL TO START . . .** With the handle in the desired position, the handle is **pulled** to start the operation — the same as actuating a conventional "Start" button.

C **PUSH TO STOP . . .** Pushing the handle immediately stops the operation. "PPS" single-point control is safer in emergencies because there is never a delay to find the right button.

Tested, Accepted ... and Acclaimed

Leading manufacturers and designers of new equipment, plant engineers and maintenance men, and operators everywhere who have worked with and know the "PPS" are universally sold on its benefits. Although it is revolutionary and relatively new, the "PPS" has been thoroughly tested on innumerable installations and found OUTSTANDING.

IT WILL PAY YOU TO KNOW MORE ABOUT THE ARROW-HART "PPS" SWITCH

This new concept in motor control can help solve your present tough control problems . . . and help you build peak performance into your new designs. Use the coupon, attached for your convenience, to send for completely descriptive literature including a sample Target Sheet for plotting your circuit requirements.

Industrial Control Division
THE ARROW-HART & HEGEMAN ELECTRIC CO.
103 Hawthorn Street, Hartford 6, Conn.

Please send me ☐ *complete information about the Push-Pull Selector Switch.* ☐ *Also the A-H Design Story folder featuring Type "RA" Magnetic Motor Controls.*

NAME _____

CO. NAME _____

POSITION _____

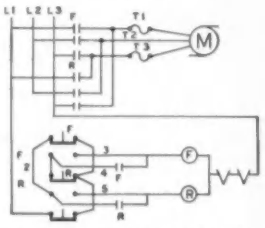
ADDRESS _____

CITY _____ ZONE _____ STATE _____

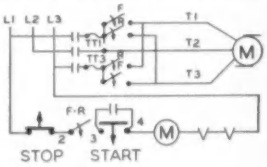
How the "PPS" works

To explain the action of the "PPS", let us look at an example; the simplest possible is the standard reversing of a motor. This example will show how the required number of magnetic units is reduced and how single-point control will serve for any number of operations.
While your own actual control application may be more complex than this example, it will simply entail using enough additional circuits to accomplish the required combinations of load and control hook-up.

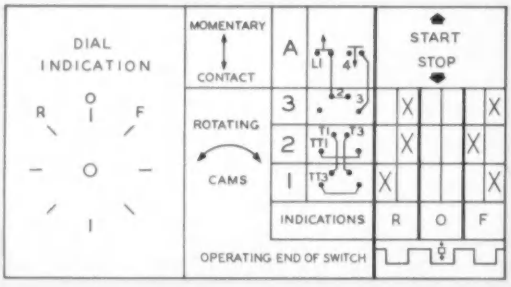
CONVENTIONAL CIRCUIT . . . This diagram shows the familiar type of reversing circuit. 3 push buttons and 2 magnetic units are required.



"PPS" CIRCUIT . . . Here the Rotating Cam Sections of the "PPS" select the circuit, and the Momentary Contact Sections operate the motor as desired. The diagram also shows the symbol used for "Stop" by pushing and "Start" by pulling. Only 1 *magnetic unit* and 1 pilot device, (the "PPS"), are required.



THE "TARGET SHEET" . . . shown here in abbreviated form, is the means by which your control requirements are translated into a diagram for the construction and wiring of a "PPS" Switch. A wiring diagram strip shield is visible from the top of every switch you buy indicating the terminals and all internal and external connections on the "PPS".



Printed in U.S.A.

ARROW·HART
INDUSTRIAL CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
HARTFORD 6, CONN., U.S.A.

Offices, Sales Engineers or Warehouses in: Atlanta, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Columbus, O., Dallas, Detroit, Houston, Los Angeles, Milwaukee, Minneapolis, New York, Philadelphia, St. Louis, San Francisco, Syracuse. In Canada: Arrow-Hart & Hegeman (Canada) Ltd., Mt. Dennis, Toronto.

closer tolerances and layer uniformity than hot tin strip, or any application requiring a solid dense layer of tin without oxide inclusions ordinarily encountered in electroplated tin strip.

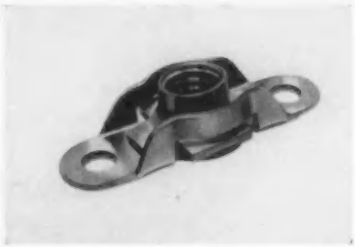
There are three standard single-clad ratios: 5/95; 10/90; 20/80. Double-clad strip is not produced at present. Overall thicknesses range from 0.005 to 0.015 in.; widths from 0.020 to 3½ in. Temper: as rolled. Metals & Controls Corp., General Plate Div., Attleboro, Mass.

For more information—
Circle 83, inside back cover

Reversible Fhp Motor

A reversible, shaded-pole motor designed for window fans is available in ratings from 1/30 to 1/12 hp. The motor is said to minimize vibration resonances and to provide essentially flat noise characteristics from 25 to 1500 cycles. Fasco Industries, Inc., Rochester 2, N. Y.

For more information—
Circle 84, inside back cover



Counterbored Self-Locking Fasteners

Reduced height, counterbored self-locking anchor and gang channel nuts have been developed to meet the requirements of the new NAS680-695

(Continued on page 310)

No doubt about it — Felt by Felters is "teased" into just the right fiber arrangement for extra resiliency and long wear.

It does not crumble under pressure or deteriorate under continuous operation. Has predictable permanent set, is not adversely affected by age, water, oil, gasoline or acid in normal concentrations. It can be used with glass, wood, metal or plastics and treated chemically to meet technical and industrial requirements.

FELT IN USE . . . Felt is widely used as filtering medium, from the respirator use shown here to filtering out impurities in oil and similar fluids. Felters Felt comes in variety of densities, has high absorption and is an effective, low-cost seal against dust and dirt.

Free Design Book

Find out about *all* the ways felt can help you in product design. Complete data in handy form, even to selection and ordering of right grades. It's yours for the asking. Send for it today: The Felters Company, 228 South Street, Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — Represented in All Principal Cities

FE5-24

use steam efficiently, economically—choose the trap with . . .

top quality...

to keep it on the job

No need for a steam trap to be complicated. All it does is discharge condensate and air from steam lines and equipment. But its importance shouldn't be overlooked. On its effectiveness can rest your economical use of steam . . . the efficiency of your process operations.

A steam trap has to be built to serve long and dependably in severe service—and that's where Nicholson quality counts heavily in terms of performance.

- **One moving part**
- **Positive shutoff—no steam waste**
- **Powerful, intermittent valve action**
- **High capacity—effective use of large orifice**

Specify Nicholson, and be sure.

Write for new
Bulletin 10-55

NICHOLSON

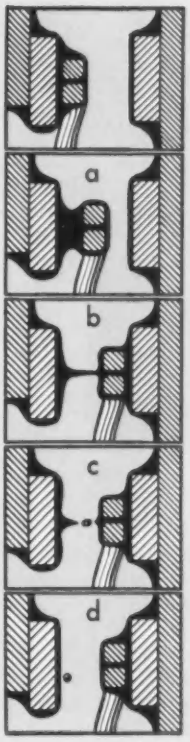
W. H. NICHOLSON and Company

TRAPS • VALVES • FLOATS • METAL PARTITIONS
LAUNDRY, DRY CLEANING AND PRESSING MACHINERY

14 OREGON STREET, WILKES-BARRE, PA. • SALES AND ENGINEERING OFFICES IN 98 PRINCIPAL CITIES

BILLIONS

OF OPERATIONS WITH **NO CONTACT WEAR OR BOUNCE**

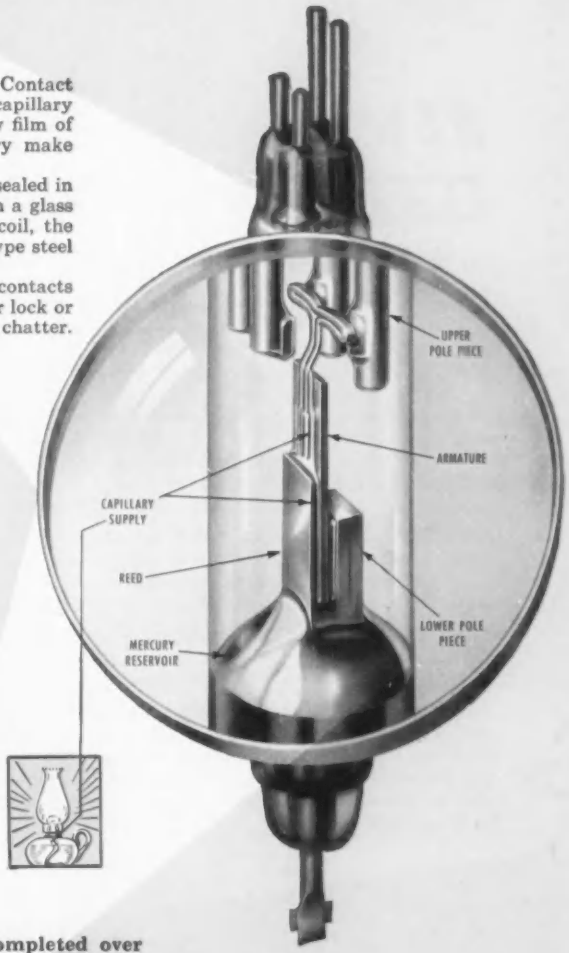


Contacts of CLARE Mercury-Wetted Contact Relays are constantly renewed. By capillary action, like that of a lamp wick, a new film of mercury coats each contact with every make and break.

The magnetic switch is hermetically sealed in a high-pressure hydrogen atmosphere in a glass capsule. Surrounded by the operating coil, the capsule is enclosed in a vacuum-tube-type steel envelope.

Unlike ordinary relay contacts, these contacts never wear down; never get dirty; never lock or weld; never get out of adjustment; never chatter.

Drawings (left) from stroboscopic photographs, show the cycle: (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. (d) The momentary bridging of the parting contacts—and the extremely fast break which ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges any mechanical chatter and prevents any chatter from appearing in the electrical circuit.



Relays on continuous test have completed over 3,000,000,000 operations with a contact load of 5 amperes at 50 volts—and are still going strong.

Send for Clare Engineering Bulletins Nos. 120 and 122. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Ave., Toronto 17. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

now

you can get this brilliant finish directly on zinc die castings!

No electroplating--no mechanical finishing!

PART AS CAST

TREATED WITH NEW IRIDITE

NEW IRIDITE® (Cast-Zinc-Brite)

brightens zinc die castings by chemical polishing, protects against corrosion

NOW, FOR THE FIRST TIME you can get a brilliant, decorative finish directly on zinc die-cast parts . . . without mechanical finishing, without electroplating! The luster is provided by the *chemical polishing* action of new Iridite (Cast-Zinc-Brite) solution. Even surface blemishes, such as cold shuts, are brightened by this new process. No electrolysis. No special equipment. No specially trained personnel. Just a simple chemical dip for a few seconds and the job is done. And, this new Iridite has been *tested and proved* in production.

CORROSION RESISTANCE, TOO! New Iridite (Cast-Zinc-Brite) provides exceptional corrosion resistance for bright-type chromate finishes . . . also guards against blueing or darkening by eliminating zinc plate formerly required in bright chromate finishing of zinc die castings.

AS A BASE FOR ELECTROPLATING—Lower mechanical finishing costs are possible where plated finishes are *required* since the brightness provided by this new Iridite may be sufficient.

LET US SHOW YOU what Iridite (Cast-Zinc-Brite) can do for you. Send us at least a half-dozen typical zinc die-cast parts for FREE PROCESSING for your own tests and evaluation. Or, for immediate information, call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified 'phone book. *IMPORTANT: when you give us samples for test processing, please be sure to identify the alloy used.*

Iridite is approved under government specifications

ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD

Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals

drawings. Made of heat-treated carbon steel, the line performs satisfactorily at temperatures up to 550 F and is approved according to AN-N-10, and drawings AN362 and AN366. Thread sizes currently included are 8-32, 10-32, ¼-28 and ⅜-24. Elastic Stop Nut Corp. of America, Union, N. J.

For more information—
Circle 85, inside back cover

Fire-Resistant Hydraulic Fluid

A fire-resistant hydraulic fluid has been developed for systems operating at temperatures above 150 F and for heavily loaded pumps and bearings. This compound is a fortified synthetic material. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

For more information—
Circle 86, inside back cover

Four-Pole, Fhp Motor

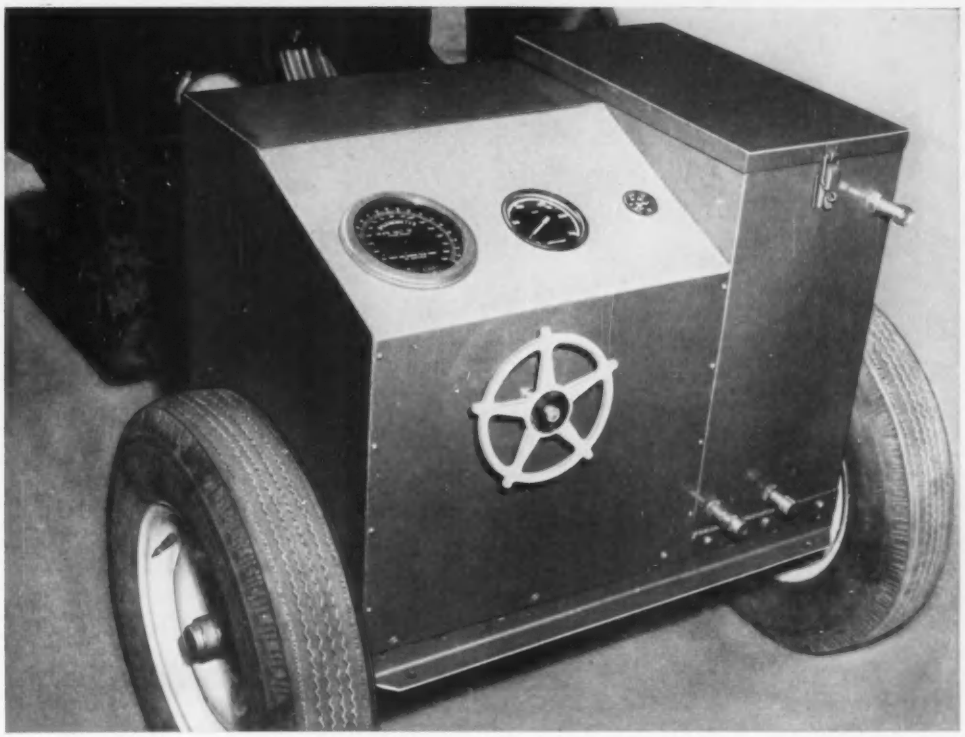
A four-pole, shaded pole motor in ratings from 1/25 to 1/10 hp was designed for unit heaters, home air conditioning units and fans. Sintered oil-less bearings are used, together with oil-retaining wicks. Available for single, two or three-speed operation. Fasco Industries, Inc., Rochester 2, N. Y.

For more information—
Circle 87, inside back cover

Double Universal Joints

A series of double universal joints is available for slow speed applications up to 300 rpm. Thirteen standard sizes provide a range from ½ to 207 hp, at 100 rpm, static torque from

(Continued on page 314)



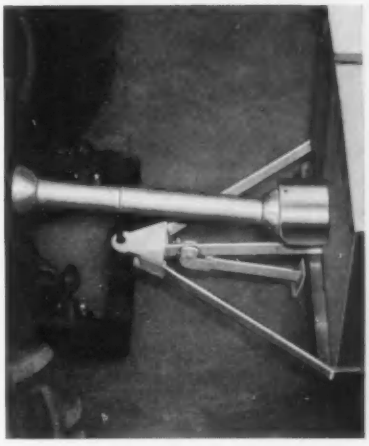
WHAT'S **NEW** AT BLOOD BROTHERS

BLOOD BROTHERS P.T.O. Drive Lines
Selected by M&W GEAR CO., Inc. for

Exciting NEW TRACTOR-TESTING DYNAMOMETER

Tractor repairmen and dealers are enthusiastic about this new test unit because it meets a real need in the farm tractor field. The only machine of its kind on the market, M&W's new dynamometer brings actual field operating conditions into the shop. Mechanics can test the pull power of farm tractors and accurately adjust ignition, carburetion and engine speed under full load for peak performance and economy.

Here's another example of the preference shown by farm implement manufacturers for Blood Brothers Drive Lines. They're selected for almost all new developments and improvements by the progressive Implement Industry because of their field-proven dependability and superiority.



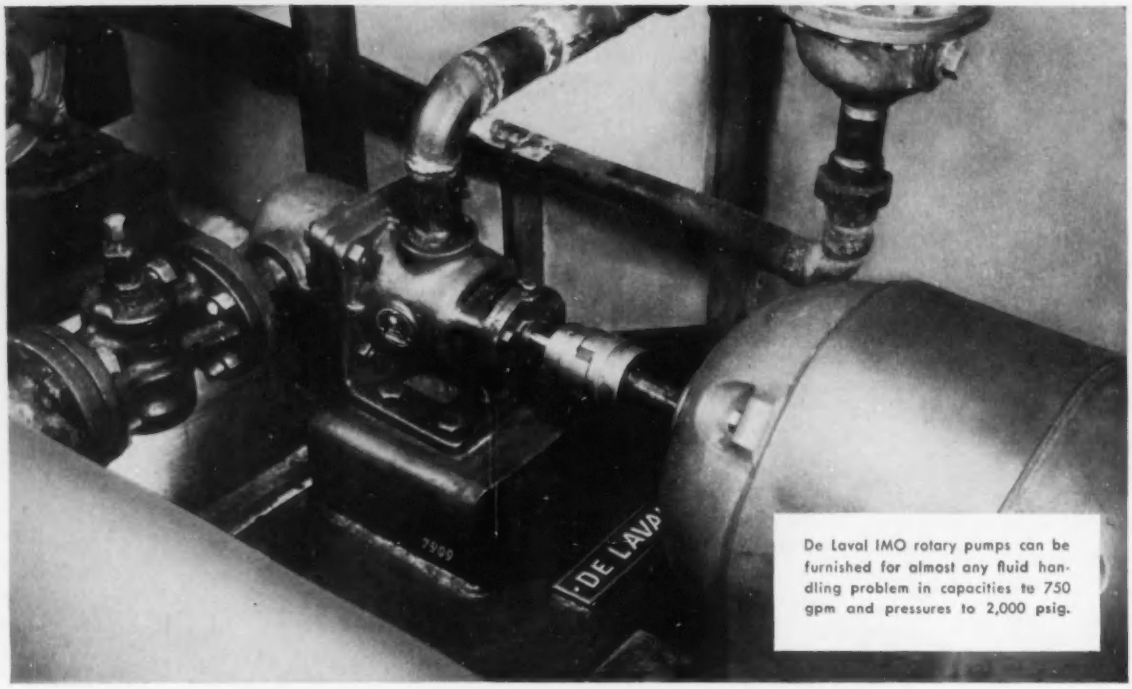
Blood Brothers Safety-Shield Drive Line handles torque loads easily—and protects mechanics working in close quarters around tractor and dynamometer in garage or implement repair shop.

FOR FARM IMPLEMENTS, MORE BLOOD BROTHERS UNIVERSAL JOINTS ARE USED THAN ALL OTHER MAKES COMBINED.

TAKES POWER AROUND CORNERS

BLOOD BROTHERS
MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 2,000 psig.

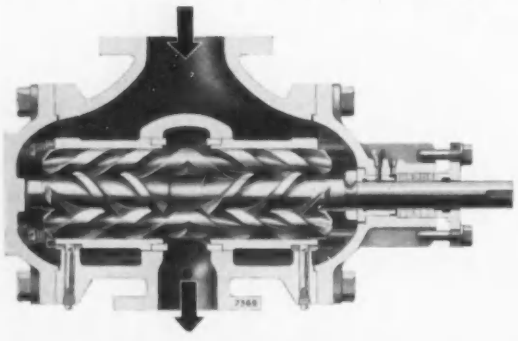
What to Look for in a Rotary Screw Type Pump

By W. J. MONGON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

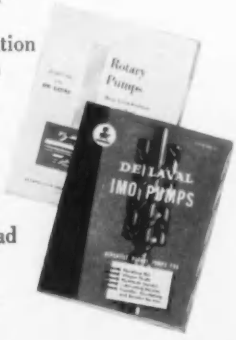
The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.



This is a cross-section of the De Laval IMO Series A322A, a positive displacement rotary screw type pump.

One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.



Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application*, contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 801 Nottingham Way, Trenton 2, New Jersey. DL-301

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FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 13, MICH.

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RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

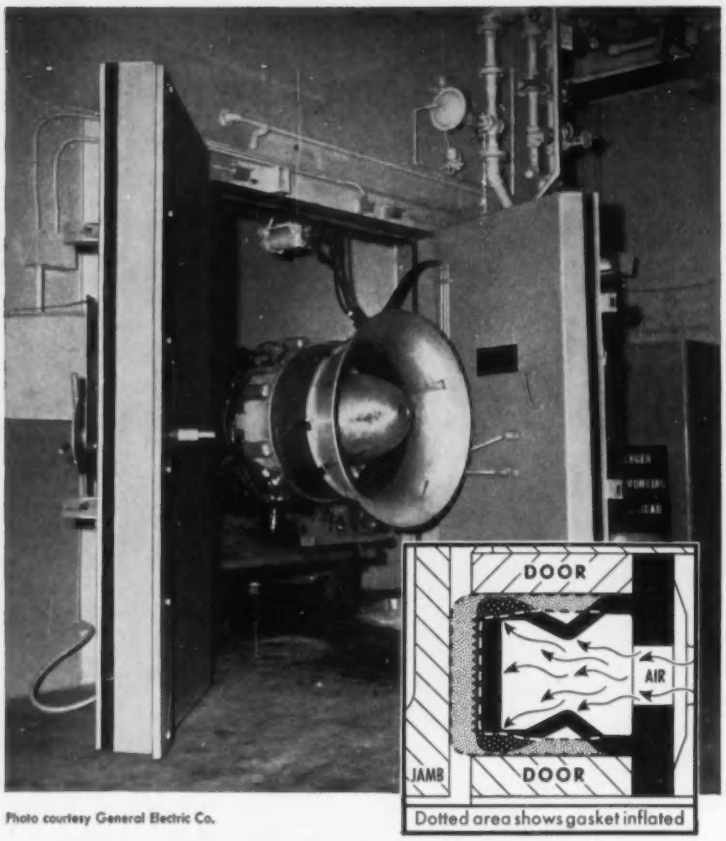

Photo courtesy General Electric Co.

Dotted area shows gasket inflated

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
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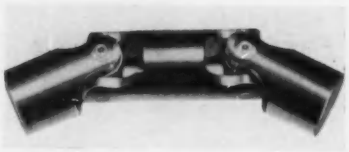


340 to 130,700 in.-lb. Maximum operating angle is 90 deg.

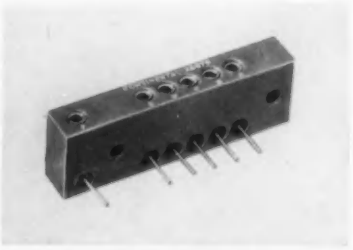
Joints can be supplied solid or bored, with hub diameters from ½ to 4 in. Standard lengths: 4 to 21¼ in. Lovejoy Flexible Coupling Co., Dept. PEN, 4800 W. Lake St., Chicago 44, Ill.

For more information—
Circle 88, inside back cover

Three-Digit Voltmeter

Having an oil-sealed stepping switch system, this instrument provides automatic measurement from zero to ±999 v d-c. Polarity indication, range selection and readout decimal point location are also automatic. Weight is 29 lb and the unit is available in either rack mount or portable models. Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.

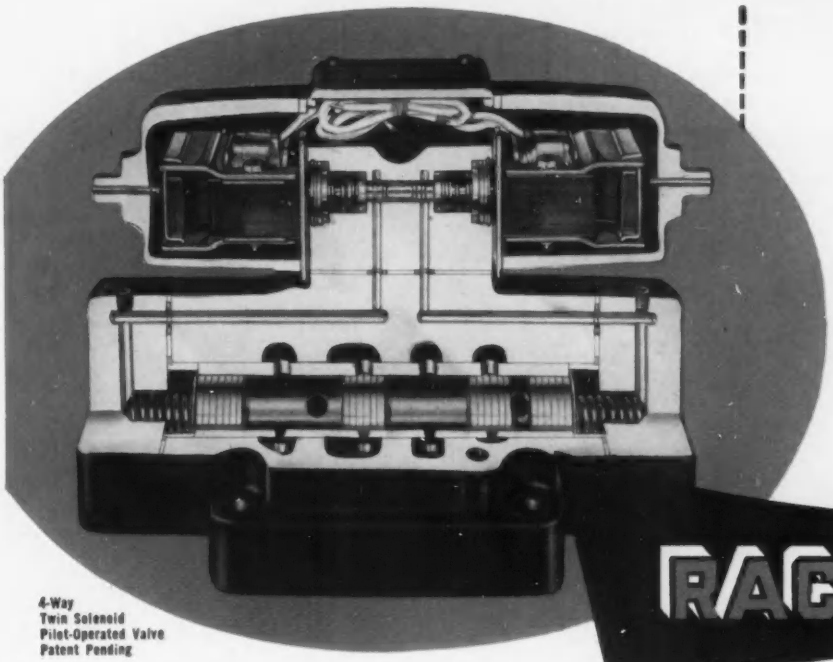
For more information—
Circle 89, inside back cover



Test Point Connector

This female test point receptacle for printed circuit wiring will accept and hold a standard 0.080 in. test

(Continued on page 318)



4-Way
Twin Solenoid
Pilot-Operated Valve
Patent Pending

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SLEEVE TYPE VALVES GIVE BETTER CONTROL

Proper control of oil flow improves the operation of your machines.

RACINE Sleeve Type Valves are designed with round drilled parts that assure smooth, control of oil to cylinders and fluid motors.

These RACINE Valves are provided with dust-proof solenoid covers — a pending patent includes a RACINE feature that prevents solenoid operation and injury to operator when covers are removed or loose.

Built to J.I.C. specifications RACINE Valves are approved for use in all critical applications. They are precision-built, compact, and rugged in design. Operating pressures to 2000 psi with full back pressure on exhaust port.

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and circuit requirements

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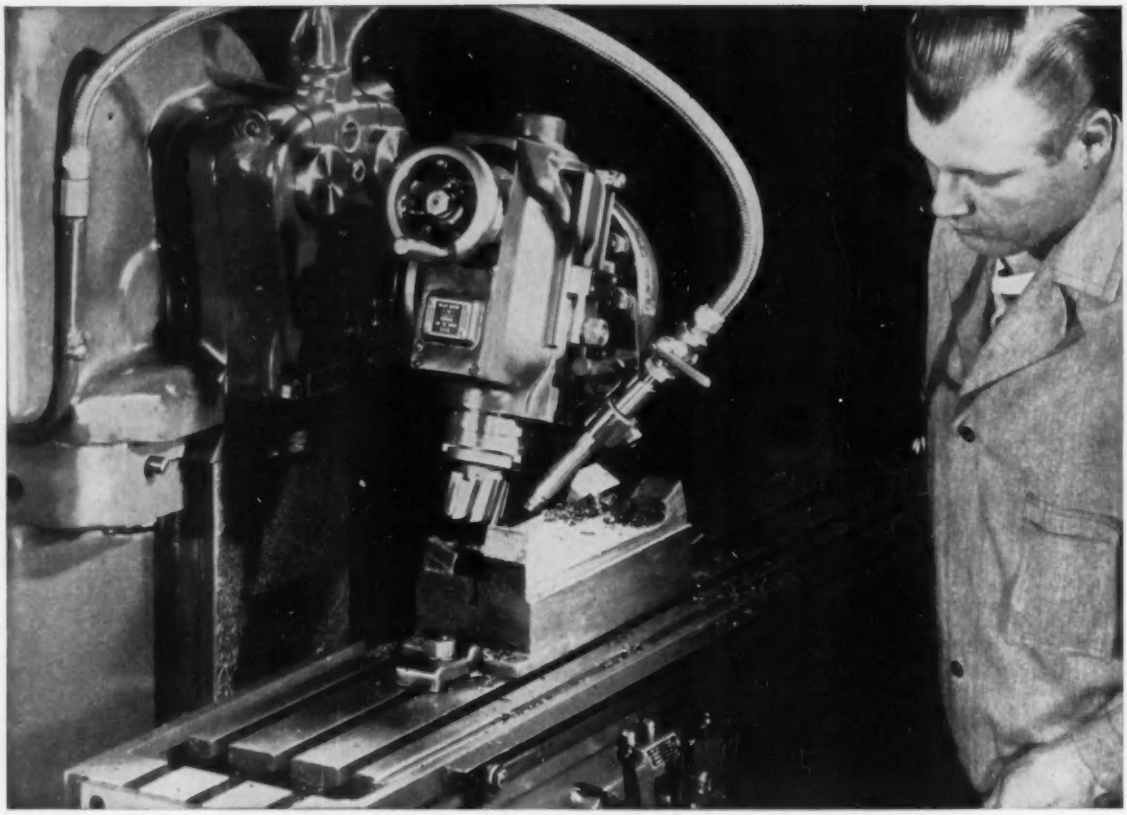
MALLORY·SHARON reports on TITANIUM



The titanium parts you design can be readily machined

• Titanium offers outstanding design advantages—a high strength-to-weight ratio, and exceptional resistance to corrosion in media where many other metals are useless. These advantages can now be realized without paying a penalty in production time.

Present grades of unalloyed titanium machine similar to 18-8 stainless steel. The alloy grades machine somewhat harder but do not approach the difficult-to-machine high temperature alloys. For the usual industrial application of titanium, where corrosion resistance is the major advantage sought, the readily-machined unalloyed grades are usually the best choice.

Mallory-Sharon guarantees that MST titanium and titanium alloy mill products contain no more than 1/10 of 1% carbon. This avoids the formation of hard carbides which greatly reduce machineability.

For bulletin on titanium machining recommendations, please write Dept. P-2.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti SHARON

problem:

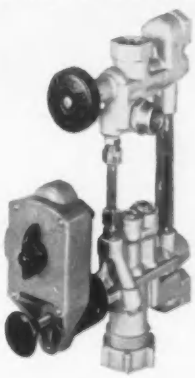
find a low-friction seal that positively seals at extremely low pressures

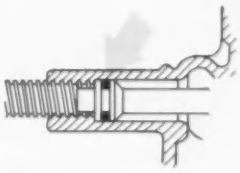
new answer:

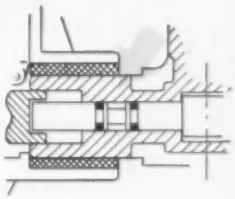
minnesota rubber's money-saving new

QUAD® RING

evidence:







THE LINDSAY COMPANY, world's largest manufacturer of automatic home water softeners, uses three QUAD RINGS in its newest valve. Lindsay tested O-rings in the valve, but O-rings leaked at very low pressures. Then Lindsay tested QUAD RINGS, a revolutionary new seal originated and manufactured by Minnesota Rubber. QUAD RINGS sealed perfectly no matter how low the pressure. The Lindsay Company also found that it could open some of the tolerances on the valve parts—and save money—because QUAD RINGS give such a good seal with low friction.

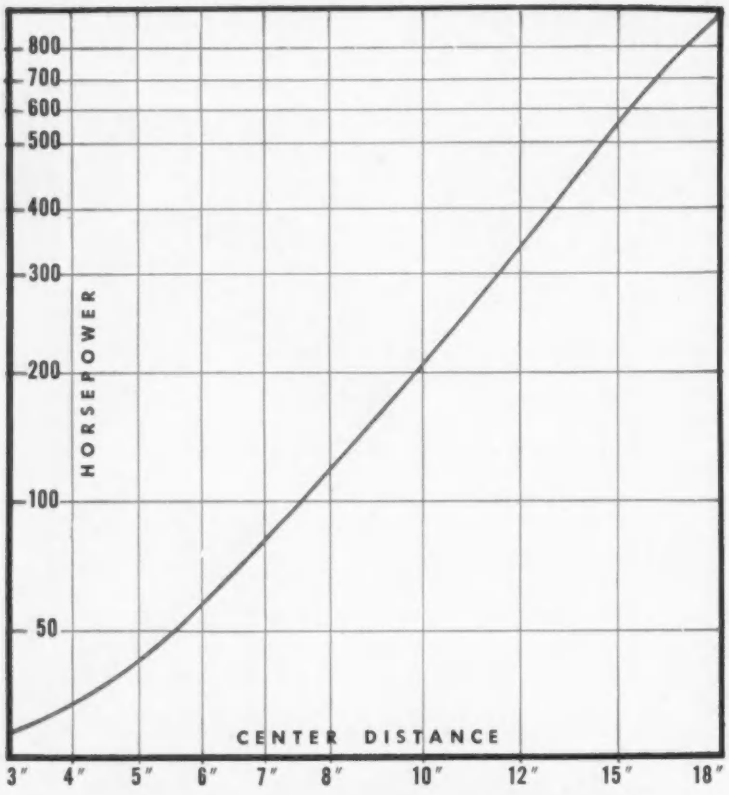
QUAD RINGS are injection molded. Denser, tougher. 4-lip action even seals at less than 1 psi! Only 60-100 micro-inch groove finish needed. No parting line on sealing surface. Eliminates "spiral twist".

free samples and data Free samples of QUAD RINGS are available with a descriptive brochure containing technical information and installation data.

minnesota rubber and gasket company

Originators of modern rubber injection molding

Dept. 202, 3630 Wooddale Ave., Minneapolis 16, Minnesota, Phone WEst 9-6781



WE LEFT COMPETITIVE RATINGS OUT OF THE CHART PURPOSELY..

. . . because we think the load-carrying capacity of Cone-Drive speed reducers is pretty impressive all by itself. Then, we've also got a lot of friends in the worm gear speed reducer business. And they make pretty fair reducers themselves.

Two things are responsible for the high capacity of Cone-Drive speed reducers. First, we use extra-heavy gears mounted on oversize taper roller bearings in reinforced, heavy housings. Extra "beef' alone accounts for part of our capacity.

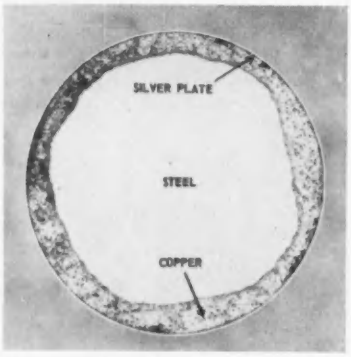
Even more important, however, is the Cone-Drive double-enveloping worm gear design. Here, we literally wrap worm and gear around each other to put ⅛ of all teeth in continuous full-depth contact. This results in spreading tooth contact over a greater area, reducing pressure on individual teeth, increasing load capacity and life of the gearing.

Ask for Bulletin 600C without obligation.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

probe. Molding body is mineral-filled Melamine (MIL-P-14D, Type MME), and is designed for right angle mounting. Six floating type contacts are made of spring temper phosphor bronze, gold plated over silver for low contact resistance and ease of soldering. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 90, inside back cover



Silver-Plated Copper Wire

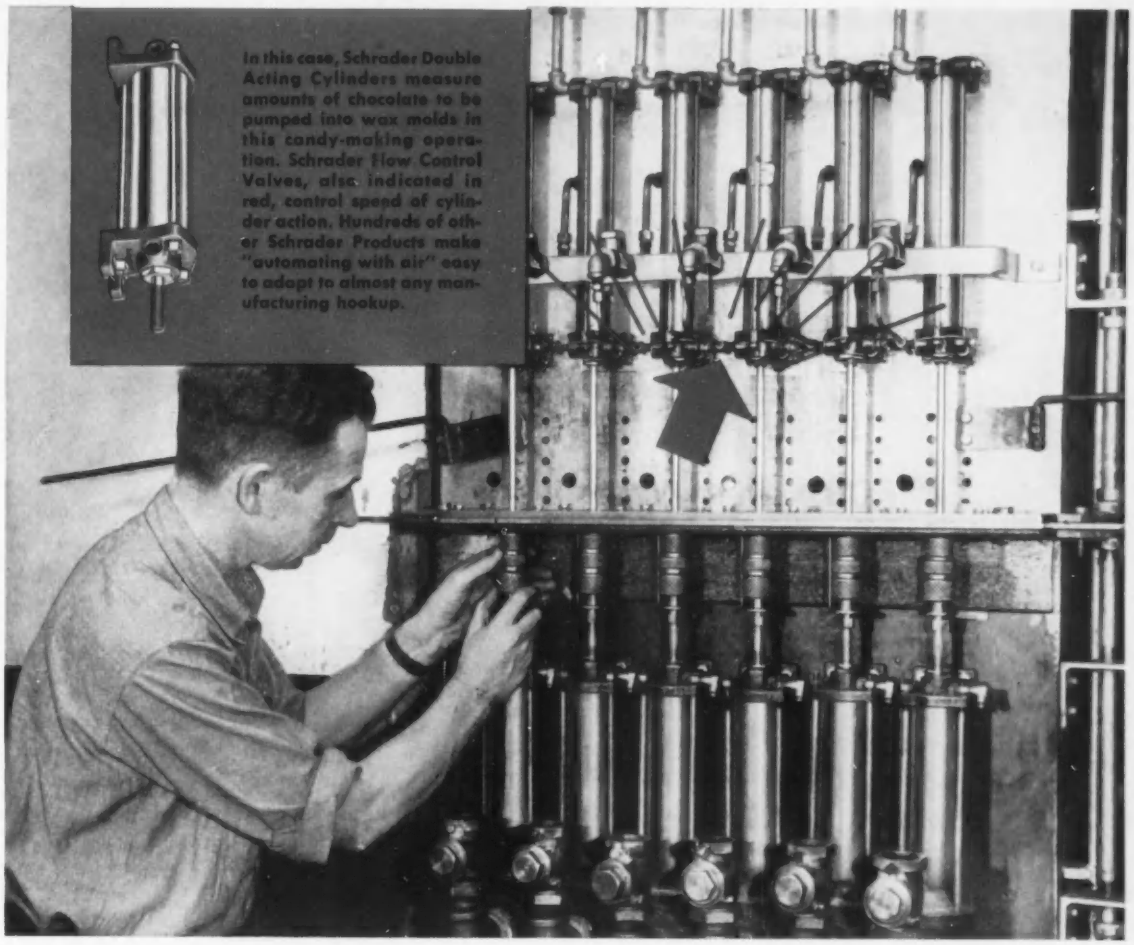
Silver-plated copper or copperweld wire of No. 16 through No. 20 gage is produced with a degree of uniformity of plating of within 1 per cent. After plating, this material can be redrawn down through No. 40 AWG, maintaining the same proportion of silver plate as was originally deposited. Times Wire and Cable Co., Wallingford, Conn.

For more information—
Circle 91, inside back cover

Alloy for Investment Casting

This alloy is a nickel-base, high-temperature alloy containing chromium, molybdenum, iron and boron with aluminum and titanium as precipitation-hardening agents. It is produced both by air-melting and vacuum-melting techniques. It is reported to have a higher yield strength than any other production alloy with comparable strength above 1400 F. The alloy also has good room-temperature ductility, a very low strategic alloy content, and it exhibits a remarkable resistance to overaging at service temperatures

(Continued on page 322)



In this case, Schrader Double Acting Cylinders measure amounts of chocolate to be pumped into wax molds in this candy-making operation. Schrader Flow Control Valves, also indicated in red, control speed of cylinder action. Hundreds of other Schrader Products make "automating with air" easy to adapt to almost any manufacturing hookup.

Schrader Air Products fill candy molds with chocolate measured to ± 1 gram

Problem: To mass-produce candy figurines, filled solid with chocolate—a tricky sweet to handle. **Solution:** One Buffalo company uses a battery of Schrader Air Cylinders which measure the chocolate to within one gram, and precisely, neatly, swiftly fill the figures.

The uses of Schrader Air Products are limited only by producers' imaginations. Versatile, safe, simple and fast, the hundreds of different units in Schrader's complete line can be employed singly or in combinations to perform automatic operations. And wherever air is used, economies are gained that increase its efficiency even more.

Think air whenever you think automation—in holding or positioning work, moving scraps or chips, or synchronizing actions. Upon request, Schrader engineers will assist you in planning for your best use of air, and in selecting the products best suited to your applications. Outline your problem and we'll be glad to help. Or send for the latest informative booklets which show Schrader Air Products that will simplify your production.

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FIRST NAME IN THE USE OF AIR
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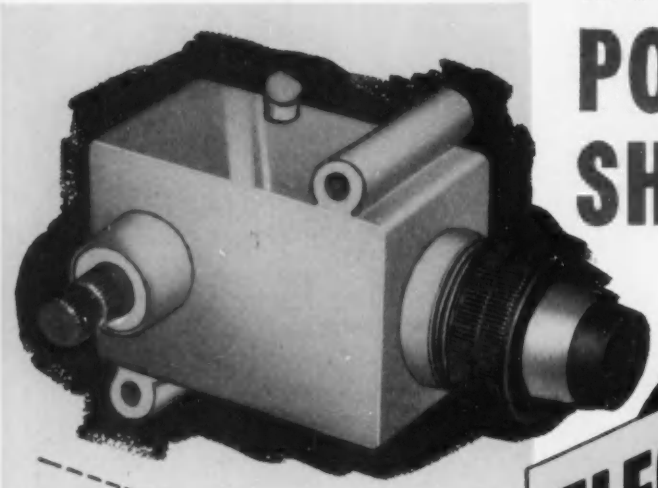
NOW AVAILABLE...

the *One* hermetically-sealed rotary switch WITH POSITIVE SHAFT SEAL!



H10-7
actual size

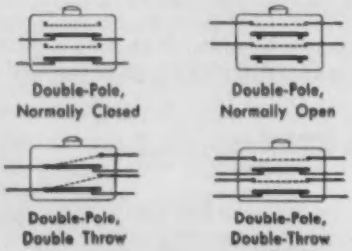
ELECTRO SNAP

- The only rotary switch with seal bonded to BOTH shaft and case!
- Leakage rate LESS than 1 micron/cu. ft./hour! Full rating to 70,000 ft.
- Choice of adjustable or fixed actuating arms.
- Full travel of 120°.
- Drawn steel case . . . 2-bolt rigid mounting!

SPECIFICATIONS

ELECTRICAL RATING	
125/250 V a-c	15 Amps
30 V d-c (Resistive)	15 Amps
(Inductive)	10 Amps
Pretravel	15° Min.
Movement Differential	10° Max.
Overtravel	105°(Approx.)
Min. Mechanical Cycles	100,000
Min. Electrical Cycles	100,000
Operating Force	1 in.-lb. (Approx.)
Overtravel Force	3 in.-lb. (Approx.)
Difference in Operating and Reset Point Between Each Pole	0° –30° Max.
Ambient Temperature Range (Higher Temperatures Available)	–100 F to + 250 F
Weight	6 ozs. (Approx.)

CONTACT ARRANGEMENTS



Double-Pole, Normally Closed

Double-Pole, Normally Open

Double-Pole, Double Throw

Double-Pole, Double-Throw 4 Circuit

Specify ELECTRO-SNAP H10-7 for the only rotary switch that is *positively* hermetically sealed — not merely equipped with a tight-fitting packing around the shaft. The H10-7 seal is bonded to both shaft and case, which is evacuated and pressure filled with a dry inert gas. Repeated actuations will not loosen the rigid 2-bolt mounting, and the splined shaft will not permit slipping of the actuator arm.

Simultaneous make-and-break (regardless of speed of the actuator travel) of up to 4 separate circuits permits reversing of 3-phase motors, substitution for expensive relays, etc. Designers can make excellent use of this electrical versatility and freedom from environmental worries. Obtain more information on the H10-7 by writing direct to:

ELECTRO-SNAP
SWITCH & MFG. CO.
4246 W. LAKE ST. • CHICAGO 24, ILL.

Why Parker O-rings seal better and last longer!

For trouble-free leakproof sealing, you can depend on precision-molded Parker O-rings. Laboratory and service tests check every detail of the manufacturing process. Precision-molding by exclusive methods assures accurately sized O-rings. And we have molds for over 296 standard O-ring sizes!

From Parker you get exactly the *right* O-ring for your *specific* application. We invite you to prove by comparison tests how Parker O-rings seal better and last longer. Our engineering service will be glad to help you with designing problems. Mail the coupon or ask your Parker O-ring distributor for catalog.

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Section 521-U
The Parker Appliance Co.
17325 Euclid Ave., Cleveland 12, Ohio

☐ Please send O-ring Catalog No. 5701

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AUTOMATIC ASSEMBLY

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Rivet-Setting Machines

Bench or floor models, full or semi-automatic. Can be adapted to solve nearly every fastening and assembly problem.

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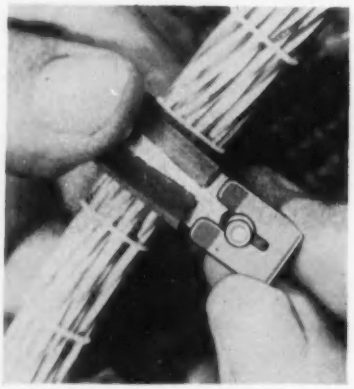
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

for periods over 1000 hr. Haynes Stellite Div., Union Carbide & Carbon Corp., 30 E. 42 St., New York 17, N. Y.

For more information—
Circle 92, inside back cover



Steel Clip for Clamp

A steel clip designed for sliding around the bolt of a wiring or hose clamp holds tension during arranging and while screwing on the nut. The clip can be inserted around a clamp bolt with an easy motion to fasten or release the clamp's prongs for repeated adjustments while arranging wiring bundles and lines on jigboards, or when fastening hose. The device is also fully effective as a washer, the maker stated. Pastushin Industries, Inc., 5651 W. Century Blvd., Los Angeles 45, Calif.

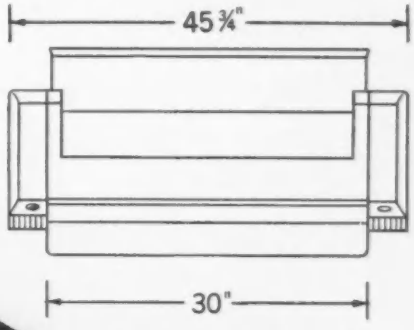
For more information—
Circle 93, inside back cover

Variable Voltage Transformer

A variable transformer that measures $3\frac{7}{8}$ x $3\frac{7}{8}$ x $3\frac{1}{2}$ in. gives a 0-132 v or 0-120 v output, both from 120 v in-

(Continued on page 326)

At Last! A Small Whiteprinter that Makes BIG Prints!



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NEW! BRUNING Copyflex Model 300!

Brings "Inside" Reproduction within the Means of the Smallest Engineering Firm or Department!
Now, with your low-cost, versatile Model 300, you can make high quality prints when you want them—rapidly, privately, and in any quantity. You can exercise complete control over valuable originals at all times.

Provides Large Companies an Economical Way to Supplement Main Reproduction Centers!
With its compact size, big printing width, and low cost, the Model 300 is an ideal helper for your big reproduction machine. Strategically located throughout your company, Model 300s can bring new speed, convenience, and efficiency to your reproduction operations.

Here it is! The compact, low-cost reproduction machine that offers all the versatility and big printing width of a large, expensive whiteprinter!

Just think—you can make sharp, black-on-white prints in seconds of a drawing or tracing up to 30 inches wide by any length. And anyone can operate the Model 300 after only brief instruction. One fingertip control turns the machine on or off and regulates its speed. Exposure and development are automatically synchronized.

The new Copyflex Model 300 is ideal for drafting rooms and offices because it can be operated anywhere without annoyance to personnel in the vicinity. It is clean, quiet, and odorless. No exhaust venting, plumbing, or accessory equipment required. It needs only a connection with a 115-volt AC outlet for operation.

If you're pressed by the boom in production for more and more engineering prints, the all-new Copyflex Model 300 is your answer! Its low initial cost combined with outstanding economy and convenience of operation and maintenance make it your soundest, low-cost investment of the year. Mail coupon today! You'll be glad you did!

BRUNING Copyflex

Best Process! Best Machines! Best Selection of Materials!

Specialists in Copying Since 1897

CHARLES BRUNING COMPANY, INC., 4700 MONTROSE AVE., CHICAGO 41, ILL.
in Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

CHARLES BRUNING CO., Dept. 113-O
4700 Montrose Ave., Chicago 41, Ill.

Please send me information on the all-new Copyflex Model 300.

Name_____ Title_____

Company_____

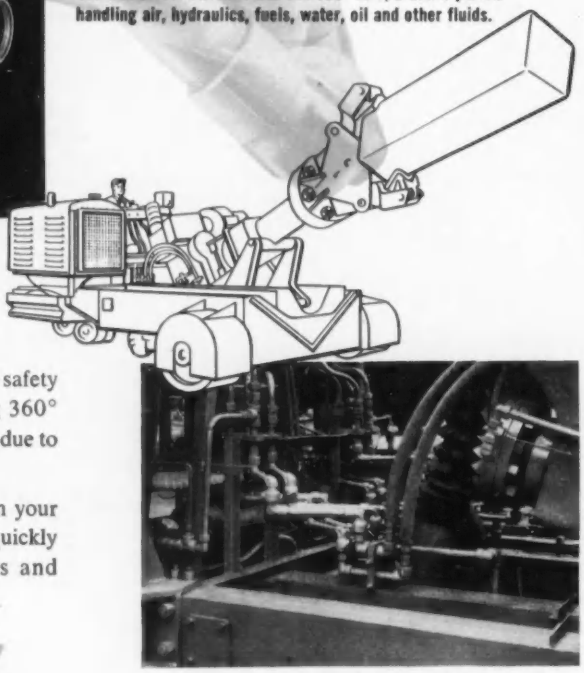
Address_____

City_____ County_____ State_____

CHIKSAN

Works wonders with hydraulic lines

Chiksan Swivel Joints rotate full 360° in 1, 2 and 3 planes handling air, hydraulics, fuels, water, oil and other fluids.



CHIKSAN SWIVEL JOINTS

Give metal lines the flexibility of rubber with the safety and service life of steel. And with free swiveling 360° rotation, Chiksan Swivel Joints eliminate line failure due to bend radii and torsion fatigue.

Investigate Chiksan Swivel Joints for application in your plant and on your products. Their modest cost is quickly repaid in savings of down-time, replacements and maintenance.

Installed on hydraulic lines of a Salem-Brosius forging manipulator, these Chiksan Swivel Joints have been in continual service for over 3 years with no down-time to date.

CHIKSAN

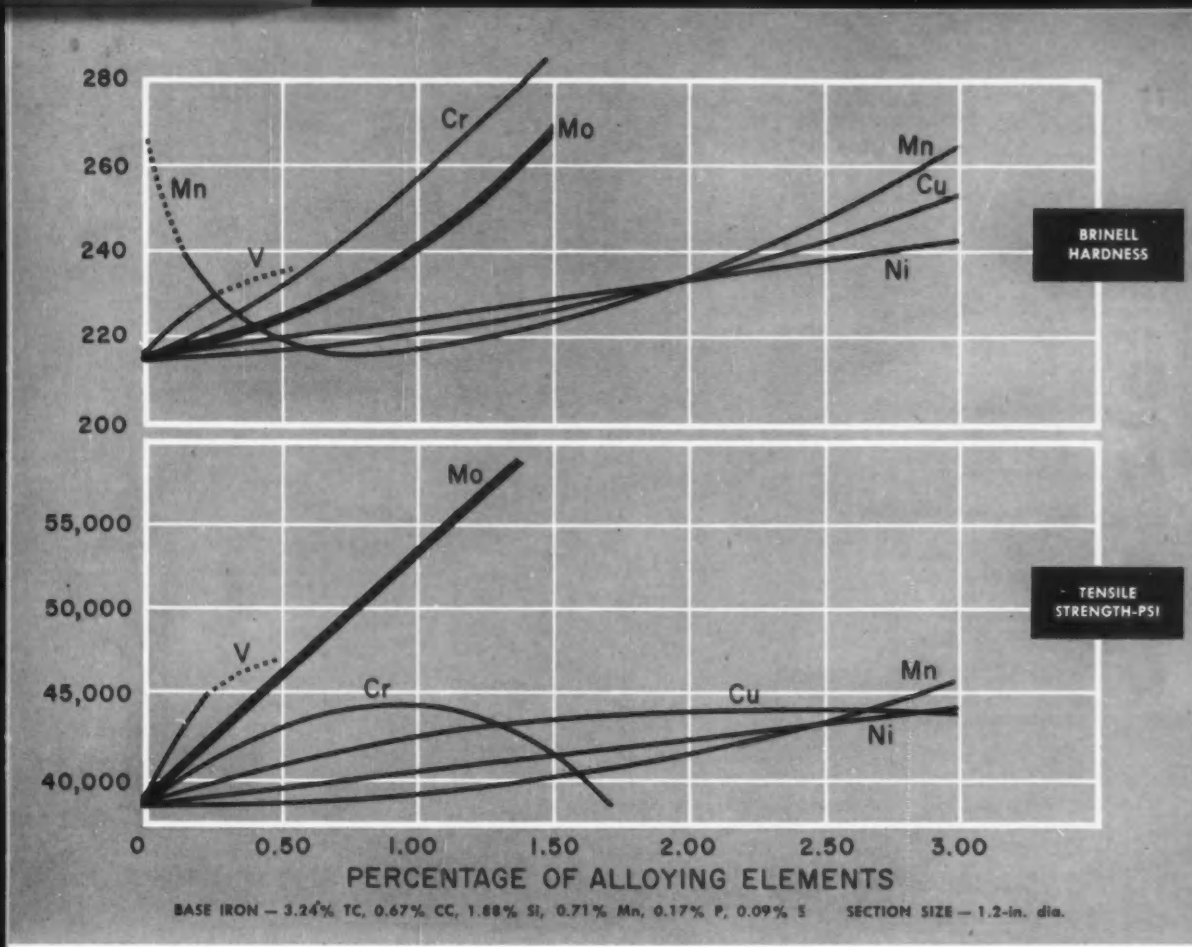
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

fmc

FOR FREE CATALOG WRITE DEPT. 1711

CHIKSAN COMPANY — BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division) Houston 1, Texas • Chiksan Export Company • Chiksan of Canada, Ltd., Edmonton, Alta.



Note how additions of moly, up to 1.5%, produce proportional improvements in strength. And, with moly, hardness increases much more slowly. It means higher strengths can be used with less danger of impaired machinability.

each ½% Moly adds 7000 psi to strength of cast iron...

A little moly adds a lot of strength – for molybdenum increases strength more than any other common alloying element, with the exception of small vanadium additions. A rule of thumb is that fifty points of moly raise tensile strength 7000 psi. And without sacrificing toughness. Actually, moly improves toughness at least as much as strength.

What's more, versatile moly aids in obtaining uniform response to heat treatment . . . and in producing machinable, growth-resistant castings. Moly is easy to use, too.

With most grades of cast iron, moly requires no change in the character of the charge, normal melting practice, or the base metal. And foundrymen like the fact that the small additions necessary may be made at the spout or in the ladle.

Write now for "Why Moly Iron". It's the full story of how and why moly adds strength faster than hardness, how it increases fatigue and torsional strength—in short why moly makes better cast iron. Climax Molybdenum Co., Dept. 61, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM

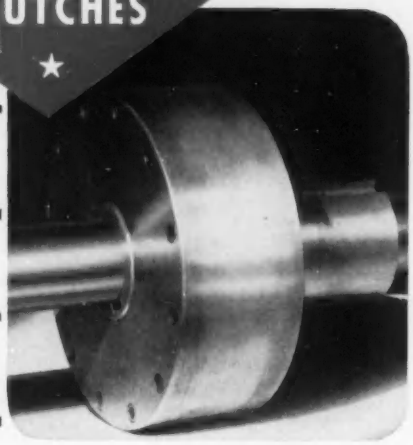
FOR POWER CONTROL DESIGNS USE
HILLIARD
Over-Running
CLUTCHES

1 LONG LIFE because the rolls have no localized wear points.

2 NO JAMMING even after long wear.

3 ACCURATE because of individual spring pressure on each roll.

4 RENEWABLE CAM SURFACES for increased life without machining or new parts.



50 YEARS of satisfactory service proves you can depend on Hilliard Over-Running Clutches and Couplings for long service on—

- DUAL DRIVES for pumps, fans, blowers and boiler stokers. (Many installations have a record of over 20 years without repair.)
- TWO SPEED DRIVES for dry cleaning machines, laundry equipment, conveyors, paper processing machines, slitters, forming rolls and automatic machinery.
- RATCHET ACTION for printing press ink rolls, coal feeders, press feeds, honing machines, bakery equipment and conveyors.
- BACK STOP SERVICE on textile machines, speed reducers, elevating conveyors and in combination with ratchet feeds.
- WRITE TODAY FOR BULLETIN 231 WITH COMPLETE INFORMATION.

OTHER HILLIARD CLUTCHES:

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.

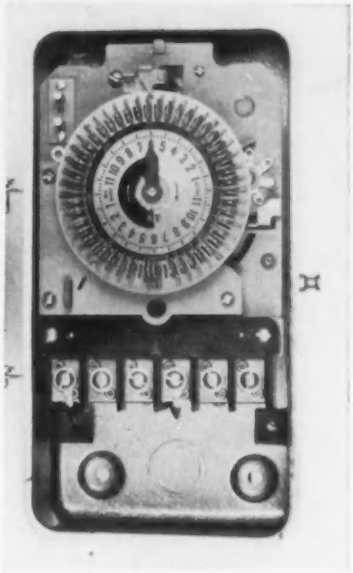
★ CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

THE HILLIARD CORPORATION
MANUFACTURING CLUTCHES FOR OVER 50 YEARS
101 West Fourth St., Elmira, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

put. Maximum output current for both models is 1.24 amp. Maximum load rating for the Model PA-1 is 165 va, for the PA-1L, 150 va. Standard Electrical Products Co., Dayton, Ohio.

For more information—
Circle 94, inside back cover



General Purpose Time Switch

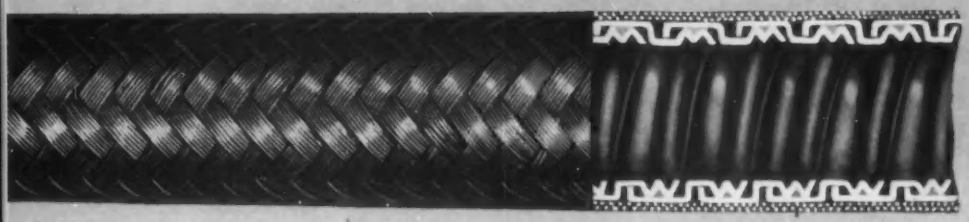
A time switch with a multi-tripper dial for flexibility of time setting is for use wherever many varied schedules are required during a 24-hr period. Slots are placed at each ¼ hr point on the dial. Minimum on-time can be as short as 15 min with a minimum on-off cycle of 45 min. Voltage for the new timing device is 120, 240, 480 v and frequency is 60, 50 or 25 cps. Power source is a 4 w motor with a greased rotor that assures positive operation from —50 F to 150 F. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 95, inside back cover

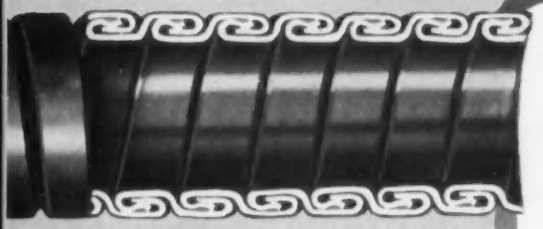
Nickel Cadmium Battery

Ranging in sizes smaller than a cigarette lighter and from ½ to over 150 amp-hr capacity, these miniature sintered plate storage batteries are for use in airborne or portable electronic, instrument and communications equipment. They have useful

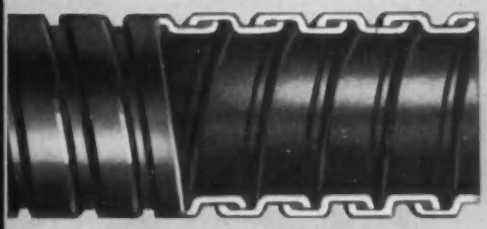
(Continued on page 331)



TYPE FP WIRE BRAIDED



HEAVY DUTY INTERLOCKED



LIGHTWEIGHT SQUARELOCKED
Unpacked, cord packed, light asbestos packed, heavy asbestos packed

VIN-LOK
alvanized Lined
ainless Steel Lined

FLEXIBILITY

DEFIES HEAT...FATIGUE ABRASION...LEAKAGE

Penflex is ruggedly built hose with all of the flexibility required, plus the toughness and durability of metal. No matter how hot the material to be conveyed Penflex cannot be cooked like ordinary hose. It stubbornly defies rough abuse, abrasion and crushing.

From 1/8" I.D. to 24" I.D. . . . bronze, galvanized steel, or stainless steel . . . from an air compressor line to a diesel exhaust, Penflex makes them all for industry. And Penflex "Flexineering"—the science of applying flexible tubing to fit the particular needs of the job to be done—assures the right tube in each installation. When you require tubing or hose that is tight as a pipe, but flexible . . . safe at high temperatures . . . and free from metal fatigue, specify Penflex.

Penflex manufactures a complete line of four wall interlocked and seamless welded corrugated flexible tubing for industry. Write for your free copy of the booklet "Flexineering At Work."

Pennsylvania Flexible Metallic Tubing Company, Inc., 7340 Powers Lane, Phila. 42, Pa. *Branch Sales Offices:* Boston • New York • Chicago • Houston • Cleveland Los Angeles and Distributors in Principal Cities

HEART OF INDUSTRYS LIFELINES

PENFLEX

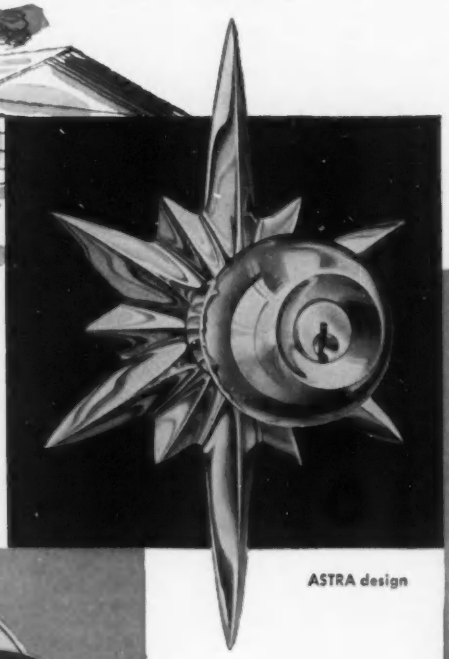
METALLIC TUBING

MUELLER BRASS CO.

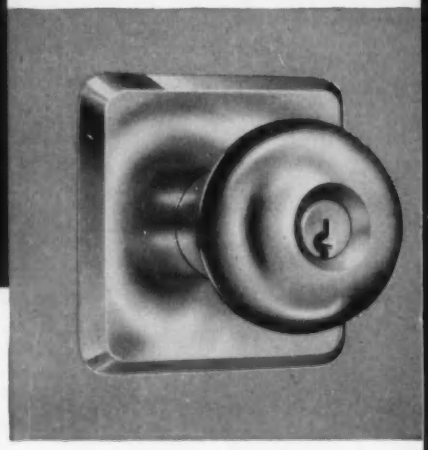
brass and bronze forgings help insure dependability and lasting jewel-like finish of distinctive SCHLAGE locks

Smart styling, handsome appearance and durability have been neatly combined by the Schlage Lock Company of San Francisco in their line of lock designs for residential and commercial use. Many important parts of these lock sets are brass and bronze forgings made by the Mueller Brass Co. The beautiful natural color, corrosion resistance, and inherent dependability of these forgings make them ideal for this purpose. In addition, the high degree of surface smoothness makes possible an exceptionally lustrous finish, as well as a perfect plating surface when required. Then, too, the use of forgings has reduced costs, cut finishing time and greatly reduced the number of rejects when compared to the sand castings that were formerly used.

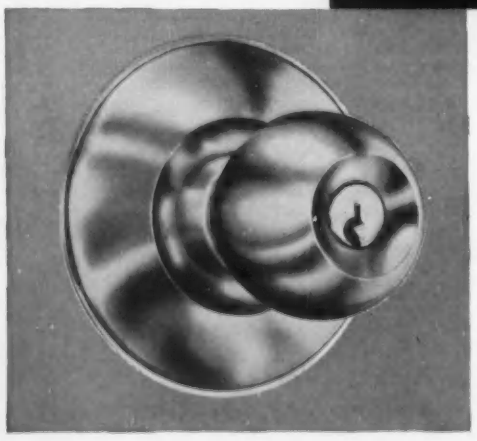
Whether you manufacture decorative hardware where finish is of prime importance or rugged assemblies that must stand up to bruising everyday punishment, it will pay you to investigate Mueller Brass Co. forgings. Strong, long wearing brass, bronze or aluminum parts, forged to your exact specifications under exacting statistical quality control standards can help you reduce costs, improve performance, and give you a better looking product. Write for our engineering manual (No. H-58565) . . . or call in one of our engineers to investigate possible forging applications in your products.



ASTRA design

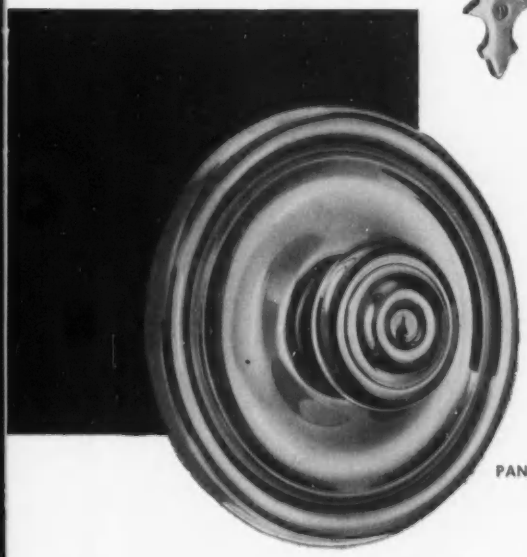


MONARCH design



MERCURY design

WAVERLY design



PANTHEON design

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings
Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys
Engineering Manual H-58563 ☐

600 Series Bearing Alloys
Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form
Engineering Manual FM-3010 ☐

METALS AND ALLOYS REVIEW

by FRANK M. LEVY
Vice-President and Director of Research

Last week one of our sales engineers was at the home office and we were talking about one of his customers in the East who manufactures milling machines which are being used for milling aircraft spars. We are supplying gibs, slide bars and wear strips to this company made of our "600" series bearing metal in rectangular rod form. The material formerly used was aluminum bronze* cast bars which they could only obtain in 36" lengths. Their engineering department estimates that costs have been reduced 50% on this component. Machining time has been reduced and impregnation of porous castings has been eliminated.

Our sales representative was curious about my experience with "600" in other applications such as this. Oddly enough, our own plant has been a pretty good proving ground. In our extrusion department, for example, we have gotten exceptionally good service from slides made of "600" and used on the die heads which are subject to pressure and extremely rough usage.

Bob Irwin of our forging department reports that the "600" strips he has used for lining the ways of our big forging presses have proved far superior to the bronzes which were original equipment. The bronze strips squashed out after protracted running. More important, the "600" strips last 10 times longer before replacement is necessary.

In our copper tube fabricating department we have a lot of automatic equipment for the production of formed tube shapes like tees and ells used in the plumbing industry. On one of the tube benders, there was no provision made for replacing worn forming slides. Our Maintenance Department reworked the machine using "600" strips as replaceable forming slide inserts. The bender is now a far more efficient machine. Because of the long life of "600", downtime on this machine has been practically eliminated.

While we were talking about these uses in our own plant, it brought to mind some other instances where the exceptionally good wearing properties of "600" have been established. A Cincinnati lathe manufacturer uses "600" in the form of counter sunk hex-headed screws on wearing strips used on lathe carriages. When the strip wears to the retaining screw the ways will not be scratched.

According to their own records, all other materials which they had tested proved unsatisfactory for the job. Another maker of precision lathes and milling machines found that after a year of exhaustive tests, the "600" metal that was used as nuts on compound slide screws outlasted competitive metals at an approximate ratio of 3 to 1 at an estimated saving of 30%.

Sliding surfaces on all kinds of machinery have different wear characteristics, as you have undoubtedly found. If you have any problems involving gibs, slide bars or wear strips that are proving troublesome, why not drop me a line or send a part print and we'll be glad to study it and make the proper recommendations.

**We manufacture 4 grades of wrought aluminum bronze.*

MUELLER BRASS CO.

PORT HURON 17, MICHIGAN

185

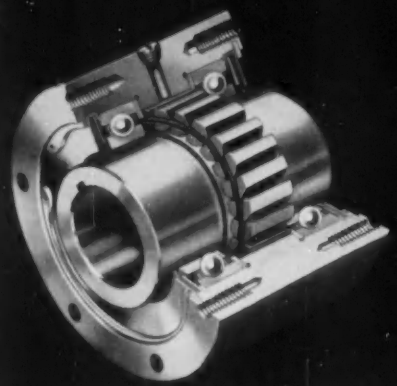
Roomful of restless men

You're looking at a roomful of design engineers. Like yourself, perhaps, they push themselves to achieve a "let's do it better for our customers" result. It's idea-creating work in a challenging mental atmosphere.

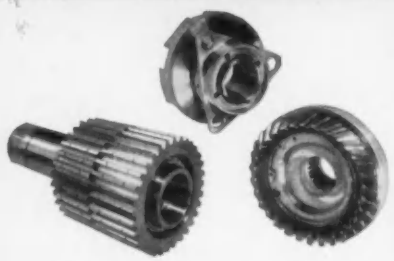
They work mostly on special clutch applications . . . been doing it for years. When a job poses a new problem they ask themselves: "Can we use one of our standard designs in this assembly rather than create a new one?" . . . More often than not their answer can be yes.

Secret of this adaptability is the result of pioneering engineering experience combined with Formsprag's basically simple design (see cutaway photo below). Imagine how these skilled designers can modify components to cover an enormous range of applications. The cost is usually only slightly above that of a standard model.

Drawing on their long experience with special application problems, Formsprag engineers are able to custom-tailor clutches from production line parts. You can rest—and plan—assured that Formsprag will design, build prototypes and volume produce special clutches to your complete satisfaction.



Standard Ball Bearing All-Purpose Formsprag Clutch. Note its simplicity of design. Between inner and outer races a full complement of sprags is inserted. Energizing springs hold sprags in contact. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.



Special application Formsprag clutches like these can be priced advantageously when the application calls for use of Formsprag's vast fund of developmental engineering know-how. Let us send you literature that discusses in detail Formsprag clutches for standard and special applications.

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive, and various industrial applications.

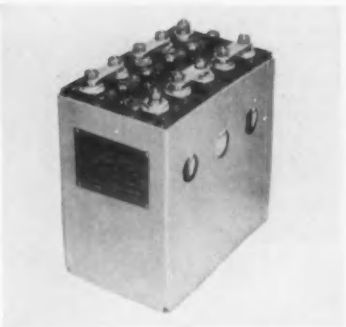
FORMSPRAG COMPANY

(A4-11B)

23607 HOOVER ROAD, VAN DYKE, MICHIGAN

World's Largest Exclusive Manufacturer of Over-Running Clutches

Distributors in principal cities



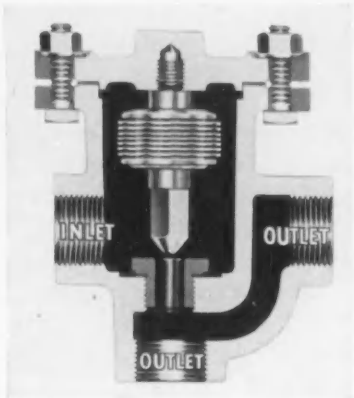
capacity in temperatures ranging from —40 F to 165 F. Nickel Cadmium Battery Corp., 68 Pleasant St., Easthampton, Mass.

For more information—
Circle 96, inside back cover

Gas and Mercury-Vapor Thyratron

A 30 amp thyratron has following ratings: filament, 2.5 v; filament current, 55 amp; peak inverse and forward 1500 v; anode current, 30 amp; peak anode current, 160 amp; anode current averaging time, 30 sec; and filament heating time, 180 sec. National Electronics, Inc., Geneva, Ill.

For more information—
Circle 97, inside back cover



Thermostatic Traps

Of cast semi-steel, cast steel or cast bronze construction, the traps are designed for installations requiring: a wide variation between startup and operating load, frequent shutdowns and startups, large amounts of air elimination on startup or during operation.

(Continued on page 334)

Here's One-Stop Shopping For All Your Molded Plastic Needs... A

Super Market

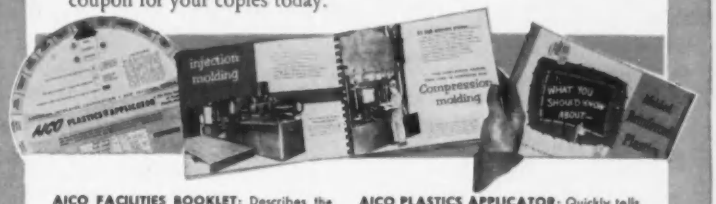
FOR CUSTOM

Molded Plastics

Here at AICO you will find, under one roof, a complete one-stop shopping service to provide product improvement, quality refinement and reduction of costs through the proper application of molded plastics. Since 1916, AICO has been a major supplier of molded plastic components to many of America's leading manufacturers. AICO's unequalled experience with every type of material and all molding methods is ready to work to your advantage too.

THREE VALUABLE AICO SHOPPING GUIDES POINT THE WAY

To see if you should convert your particular products to plastics, send for the 3 AICO Shopping Guides to the profitable use of plastics shown below. They're free... No obligation. Mail coupon for your copies today.



AICO FACILITIES BOOKLET: Describes the equipment needed to provide a complete molding service. Serves as a valuable guide to selecting a single, fully-equipped molder to do your work, and thus avoid the annoyance and waste of split responsibilities.

AICO PLASTICS APPLICATOR: Quickly tells you which plastic material will be most suitable for your product... and how it should be molded.

REINFORCED PLASTICS BOOKLET: Describes these amazing new materials... as strong as steel, as light as aluminum. Tells all about their uses.

AICO MOLDING PRECISION PLASTICS 1916-1956

A COMPLETE PLASTICS MOLDING SERVICE including engineering, mold building, compression, transfer, injection and cold molding plus the molding of Reinforced Fiberglas.

AMERICAN INSULATOR CORPORATION

New Freedom, Pennsylvania

Send me the AICO PLASTIC SHOPPING GUIDES checked below:
☐ AICO PLASTICS APPLICATOR ☐ AICO FACILITIES BOOKLET
☐ REINFORCED PLASTICS BOOKLET

Name_____

Title_____

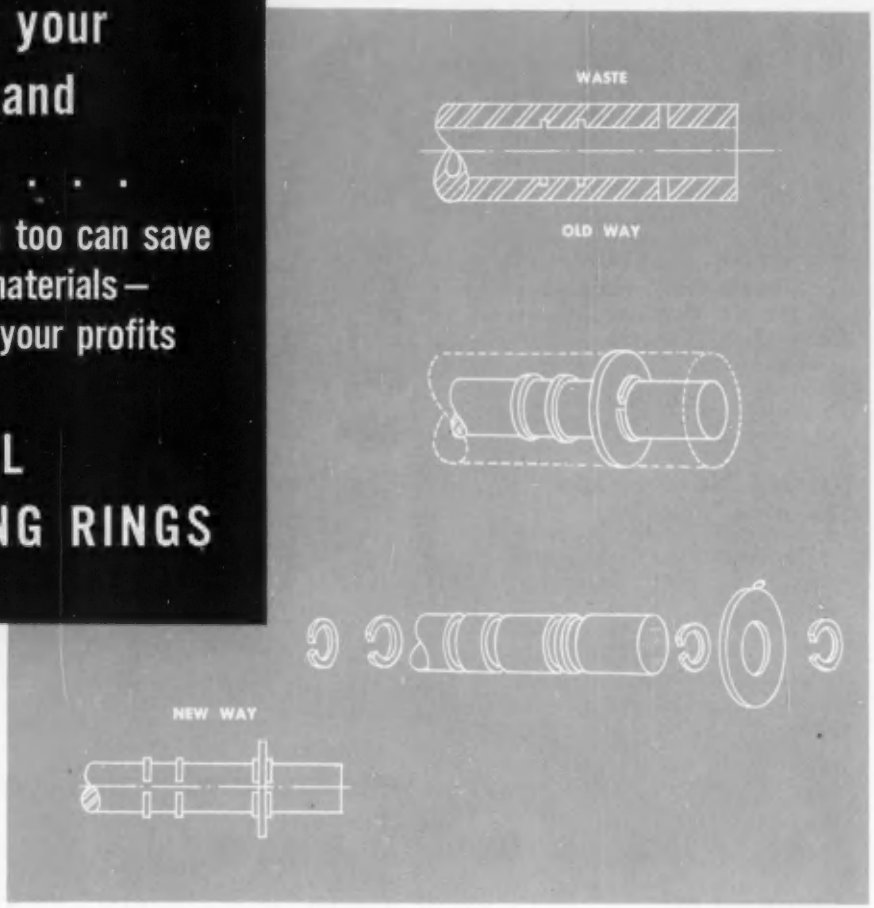
Company_____

Address_____

Examine the design of your products and machines . . .

No doubt you too can save time—save materials—and increase your profits by using

NATIONAL RETAINING RINGS



There are literally thousands of places where retaining rings will *save*, ranging from simple applications on tools, toys, small parts and gadgets to complicated heavy duty engines, large drill presses, etc., etc.

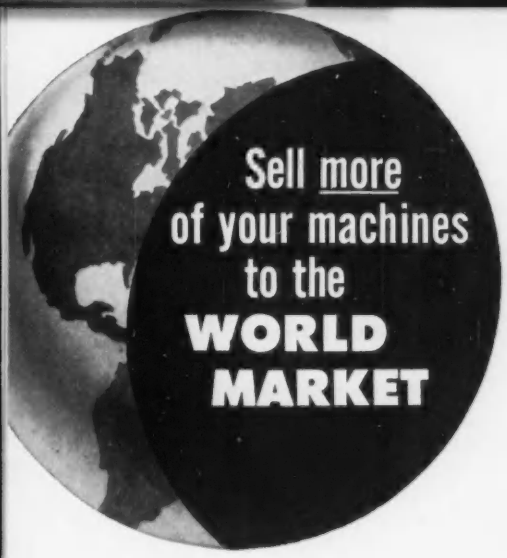
And in addition to this economy, they *improve* your products. It is wasteful to cut down shafts to make shoulders. Redesign to groove *smaller* shafts and housings and use these high-grade steel rings.

Let our engineers consult with you. Send today for folders.

Don't pass up this opportunity to increase profits.

THE NATIONAL LOCK WASHER CO.

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN, U. S. A.



Sell more of your machines to the WORLD MARKET

1. *By installing the line of Diesel Engines that is backed by world-wide sales, service and parts outlets.*

2. *Or by shipping your units—without motors—to almost any spot on earth, letting your customer install one of these diesels (at lower cost to him) at destination point!*

Perkins Diesels are in use in the following 118 countries and regions:

ADEN
AFGHANISTAN
ALGERIA
ANGOLA
ARABIA
ARGENTINA
AUSTRIA
AUSTRALIA
AZORES
BAHAMAS
BARBADOS
BELGIAN CONGO
BELGIUM
BERMUDA
BOLIVIA
BORNEO
BRAZIL
BRIT. CAMEROONS
BRIT. GUIANA
BRIT. HONDURAS
BRIT. N. BORNEO
BRIT. SOMALILAND
BURMA
CANADA
CEYLON
CHILE
CHINA
COLOMBIA
COSTA RICA
CUBA
CURACAO
CYPRUS
CZECHOSLOVAKIA
DENMARK
DOMINICA
ECUADOR
EIRE
EGYPT
FED. MALAY STATES
FINLAND
FIJI ISLES
FRANCE
FR. CAMEROONS
FR. EQUAT. AFRICA
FR. GUINEA
GERMANY
GIBRALTAR
GOLD COAST
GREECE
GUATEMALA
HAITI
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NICARAGUA
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NORTH RHODESIA
NORWAY
NYASALAND
PAKISTAN
PALESTINE
PANAMA
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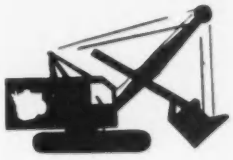
PORTUGAL
PUERTO RICO
RUMANIA
SALVADOR
SAUDI ARABIA
SIERRA LEONE
SINGAPORE
S. RHODESIA
S. W. AFRICA
SPAIN
SUDAN
SWAZILAND
SWEDEN
SWITZERLAND
SYRIA
TANGANYIKA
THAILAND
TRANS JORDAN
TRINIDAD
TUNISIA
TURKEY
UGANDA
UNION S. AFRICA
URUGUAY
UNITED KINGDOM
U.S.A.
U.S.S.R.
VENEZUELA
WEST AFRICA
YUGOSLAVIA

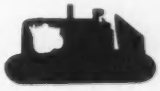


Perkins produced over 4,500,000 brake horsepower in light, high-speed diesel engines in 1955. 70 % of this output went into the world markets—where Perkins Diesels set the world standard in motors up to 120 B.H.P.

The heavy export units you produce may be the finest of their kind. But unless you can guarantee adequate service and parts facilities on a world-wide scale for the diesel engines that power those units, world markets may be hesitant to buy them.

That is why F. Perkins Ltd. believe they can help you sell more export machinery. Perkins not only make a complete line of high speed, light weight diesel engines—they have sales, service and parts outlets in 106 countries as well! (See list on this page)

Also, these versatile engines are available to specifications of your own engineering department. Deliveries can be made from Sterling sources to you or direct to your overseas branches or distributors.



Perkins maintain an engineering staff in Toronto, Canada to work with your company. Simply phone them. They will fly down to discuss applications with you. Prototype installations can be made at Toronto or at your plant.

Make sure of expert diesel service and availability of engine parts for all your export units . . . cut shipping costs and assembly headaches . . . call Perkins Toronto Office today.

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Do you need brake blocks to stop a 600 horsepower oil drilling drawworks . . . *or* small friction units to control the cycles of an automatic washer?

Thermoid is the ideal source for these and many other *friction* and *rubber* components. For 75 years Thermoid has satisfied the varied and specific requirements of design engineers for high quality, long wearing, trouble-free Hose, V-Belts, Friction Materials and Molded Rubber Parts.

Thermoid multi-plant facilities are big enough to handle your largest mass production demands . . . small enough to make *personalized engineering* service more than just a phrase.

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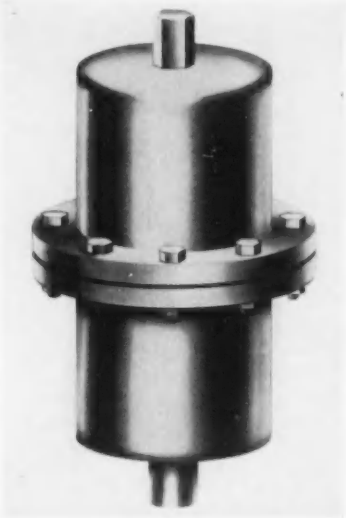
Thermoid Company
Trenton, New Jersey

Made in three series, each trap is fitted with an orifice that operates the entire pressure range, from 0 to maximum rated pressure, without necessity of adjustment. Traps are available for steam pressures up to 300 psi and temperatures up to 500 F. Inlet, outlet connections ½ to 2 in. Clark Mfg. Co., 1830 E. 38 St., Cleveland 14, Ohio.

For more information—
Circle 98, inside back cover



Hydraulic Accumulator

A hydraulic accumulator provides a positive barrier between two different fluids. Of bolted flange construction, the only replacement part required is the one-piece synthetic rubber seal.

These accumulators are being manufactured in twelve sizes, from 30 to 2800 cu in., for pressures up to 1500 psi and most materials. Spec Co., 614 Vrain St., Denver 4, Colo.

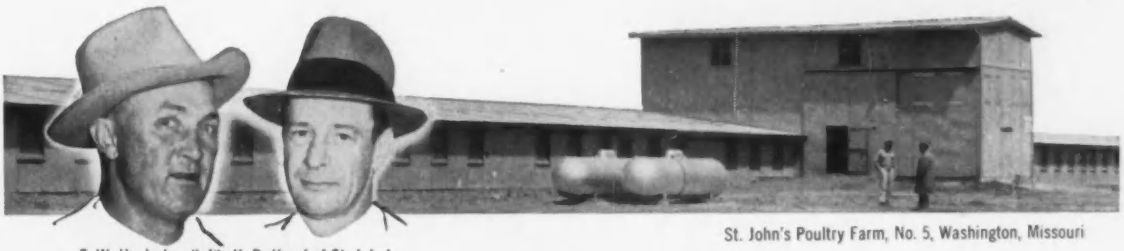
For more information—
Circle 99, inside back cover

Plug-In Circuit Design Kit

This transistor circuit design kit consists of a number of individual units each of which comprises a basic circuit element, signal source or test instrument. The basic kit of fifteen individual units permits general circuit synthesis and testing in the audio range. High frequency units may be added to extend the range.

Breadboarding of a circuit is said to

(Continued on page 336)

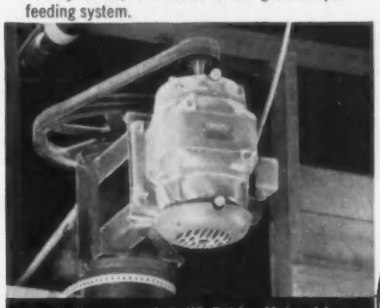


St. John's Poultry Farm, No. 5, Washington, Missouri

F. W. Hoelscher (left), K. B. Kruel of St. John's Poultry Farms, Inc. Hoelscher designed unique feeding system.

Baldor

STREAMCOOLED MOTORS help feed 120,000 chickens Automatically!



Vertically-mounted, 2-HP Baldor Motor drives screw elevator which lifts corn grain from ground level into hopper for storage.

Hammer mill, powered by a 5-HP Baldor Motor, grinds grain and blows it to weighing bin and mixer.

Special feed is mixed with ground corn. Vertically-mounted, 3-HP Baldor Motor drives mixer. All motors are single phase.

St. John's Poultry Farms, Washington, Mo., boasts one of the most time and labor saving systems for feeding chickens in the world! Six block-and-a-half long broiler buildings house 20,000 chickens each. *One man* maintains each building.

Many Baldor Streamcooled Motors power these automatic feeding systems. Splash-proof, dust-proof, totally enclosed motors keep out powder-like grain that constantly fills the air. Non-clogging external fans can't cause trouble that might stop entire system.

These same rugged Baldor Motors—proven in field use for over a third of a century—have also earned an outstanding reputation among OEM users. Baldor engineering counsel is available—without obligation—to help solve your knotty motor problems. Just contact . . .

BALDOR ELECTRIC CO.

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Chain belt carries feed in adjustable-height troughs to 20,000 broilers. Automatic timer increases frequency of delivery as chickens mature. Human hands never touch grain during entire process.

(B) NYLOK'S® SEAL *as they* LOCK

(B) NYLOK® FASTENERS stop weeping bolts, dripping oil pans, gasoline, alcohol, and air leaks. Won't vibrate loose, shrink, dry, or turn brittle. Unaffected by age, or sustained temperatures up to 250°F.

(B) NYLOK'S® are easy to take-up or back-off. Stay locked at ANY depth . . . need not be fully seated. Give smooth torque with no damage to threads or seating surfaces.

THE SECRET . . . a permanent insert of tough, resilient nylon with positive LOCKING and SEALING properties easily adapted to any (B) threaded fastener.

ELIMINATES costly locking devices and double inventory. Saves handling and assembly time.

● **WRITE** for our NEW brochure. Call (B) for quotes.

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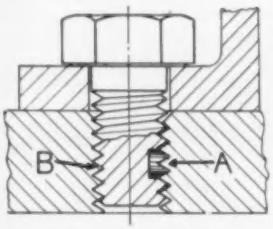
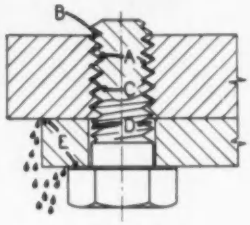
HOW NYLOK WORKS



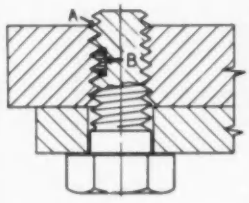
● Resilient nylon pellet (A) sets up lateral thrust which wedges mating threads smoothly together (B). All locking action is on the threads. Tight, metal-to-metal union . . . positive, leak-proof lock.

HOW NYLOK SEALS



STANDARD BOLT

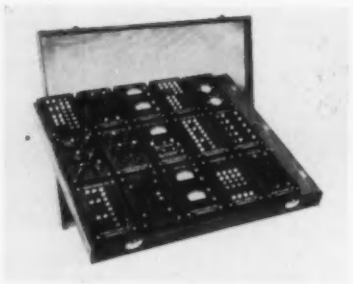
● Axial force causes load-bearing faces to meet tightly at (A). Fluid is prevented from following helical path down to flange, or bolt head. Nothing, however, prevents fluid entering above non-load-bearing faces (B) from following helical path (C) to clearance hole (D) and seeping out at (E).



NYLOK BOLT

● With NYLOK® seal, both load and non-load-bearing faces meet in tight metal-to-metal union. Fluid entering at (A) flows only as far as NYLOK pellet (B) which provides effective dam to further flow . . . puts an end to leakage.

SELF-LOCKING SELF-SEALING (B) NYLOK® FASTENERS



be eliminated since the system permits circuits to be set up in 3 to 5 min by means of color-coded pin tip leads and pin jacks connected to all circuit elements. Circuit design testing, experimenting, teaching and learning the "feel" of circuits may all be carried out.

A range of circuit components are included, such as potentiometers, fixed resistors, fixed capacitors, inductors, transformers, speakers, transistor and tube sockets, batteries, meters, junction tie point, and various signal sources and test instruments. Instant Circuits Div., Alfred W. Barber Laboratories, 32-44 Francis Lewis Blvd., Flushing 58, N. Y.

For more information—
Circle 100, inside back cover

Direct-Recording Oscillograph

This oscillograph records frequencies up to 2,000 cps. The sensitivity of its galvanometers is said to be comparable to that in photographic-type oscillographs, yet the record is instantly visible, readable and usable without further processing of any kind. No powder magazines or other processing material is required.

The unit is recommended for uses where the measured phenomena need to be monitored, or where immediate

(Continued on page 338)

There are 69 reasons why

—Diehl can build better motors. For 69 years, successive generations of Diehl motor specialists have applied their accumulated know-how to solving the power problems of widely divergent types of industries. In the smallest shops or the largest plants—all over America—Diehl men study the problem along with the customer. Name your motor requirements—no matter how "different," it's more than likely that an almost-similar situation has been recently brought to a successful conclusion with Diehl action. Here's where Diehl know-how helps you. The right answer and the right motor—*at the most reasonable cost*—can be yours, fast! Designed and built for your job. Get all the power and get it right—from Diehl.

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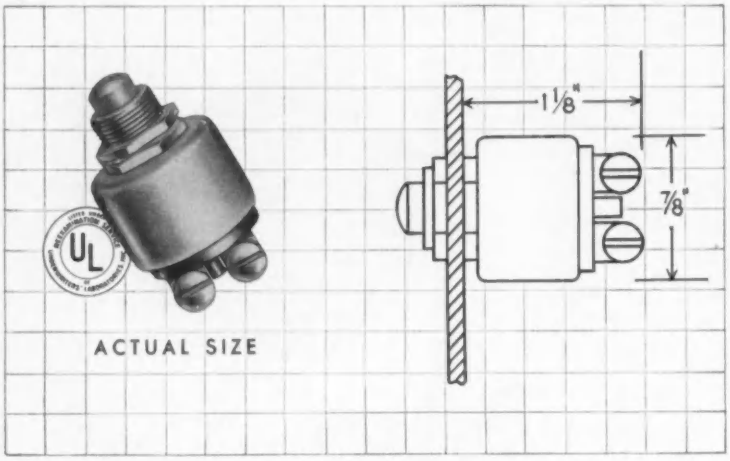
Precision, Snap-Action

Panel Mount Push Button Switch



Model "D" ACRO micro-switch

A compact, easy-to-install unit in conventional push button style

Precision switches come in all shapes and sizes. Here's an important new one by Acro that rounds out the line. Its compact dimensions conserve space behind the panel. And installation is a cinch since round holes are easiest to cut.

This little switch packs a big wallop! It's rated at 12 amps, 125 volts, ½ hp—Underwriters' listed. Mechanically, there's up to 3/16 inch overtravel. Three types of terminals are available—screw, solder or quick disconnect.

Write for Data Sheet D-1

SWITCH DIVISION

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Plants at Columbus and Hillsboro, Ohio

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recorded results are necessary or desirable. As many as six channels are accommodated on a 6 in. chart. Its galvanometers deflect a full 6 in. peak-to-peak. Chart speeds are 0.2, 1, 5 and 25 in. per sec, min. or hr. The instrument accommodates 100 ft of record, it can be rapidly loaded in daylight, and has an indicator that shows the amount of unused record.

Designed for 115 v, 60 cps operation, the oscillograph is 10x14x10 in. wide. Its operating weight, complete, is about 45 lb. Heiland Div., Minneapolis-Honeywell Regulator Co., 5200 E. Evans Ave., Denver 22, Colo.

For more information—
Circle 101, inside back cover

Working Scale Models

Clear plastic, working scale models of machinery or machine components are now being custom made. Clear colored plastic is used to emphasize important working parts or design advantages. Other parts are colorless. The models can be built to any desired scale. Industrial Planning Co., 5522 Baltimore Ave., Philadelphia 43, Pa.

For more information—
Circle 102, inside back cover

Lead Holder With Self-Cleaning Clutch

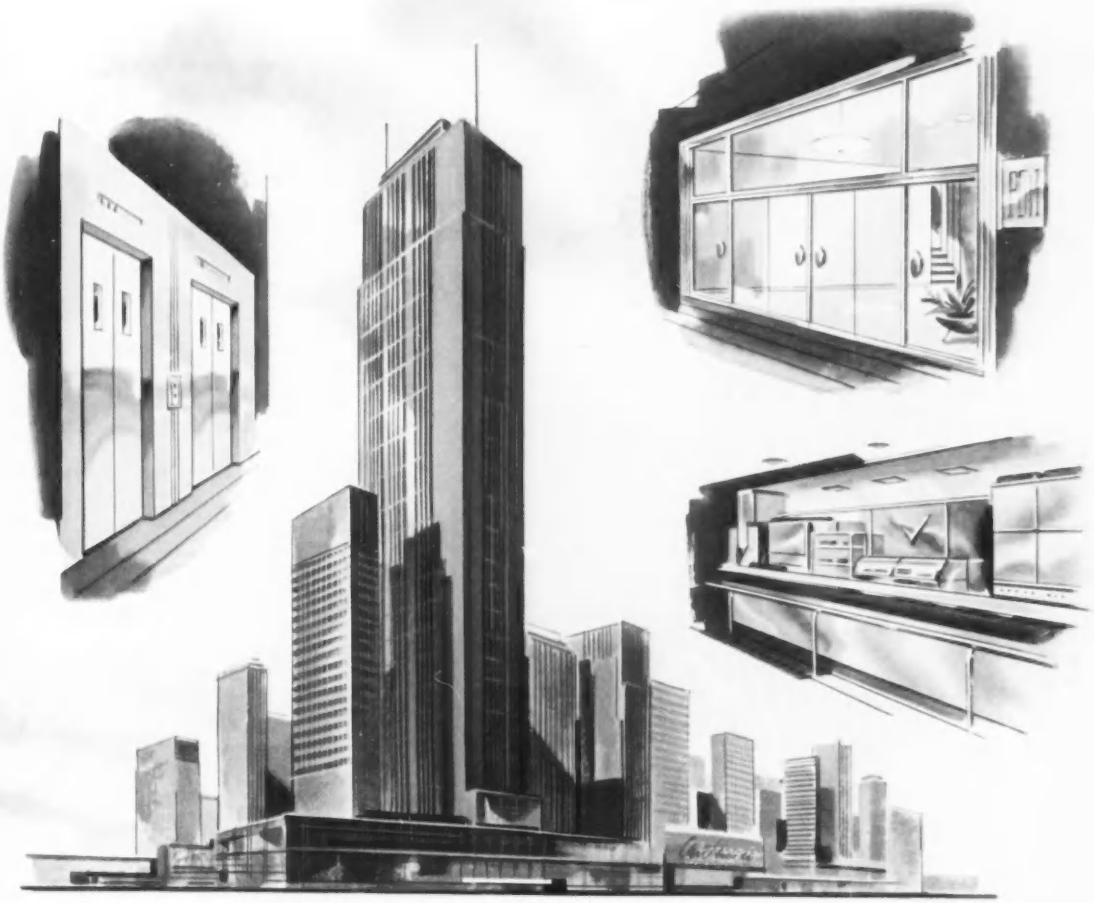
This holder possesses a self-cleaning clutch which eliminates build-up and clogging from graphite particles. It has a spring-loaded release mechanism which grasps the lead securely and operates quickly and easily. The barrel is of anodized aluminum. Tips are available in red, blue or yellow. Richard Best Pencil Co., Springfield, N. J.

For more information—
Circle 103, inside back cover

Molded Coil Kit

Molded coils arranged in varying inductances are placed on printed cards and packed in transparent plastic boxes. There are four basic kits, covering the inductance range from 0.15 uh to 1000 uh. National Coil Company, Sheridan Wyo.

For more information—
Circle 104, inside back cover



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ENGINEERING BULLETIN
ON MICRO-BEARINGS
Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, NEW HAMPSHIRE

Subject: **MEASUREMENT OF RADIAL RUNOUT**

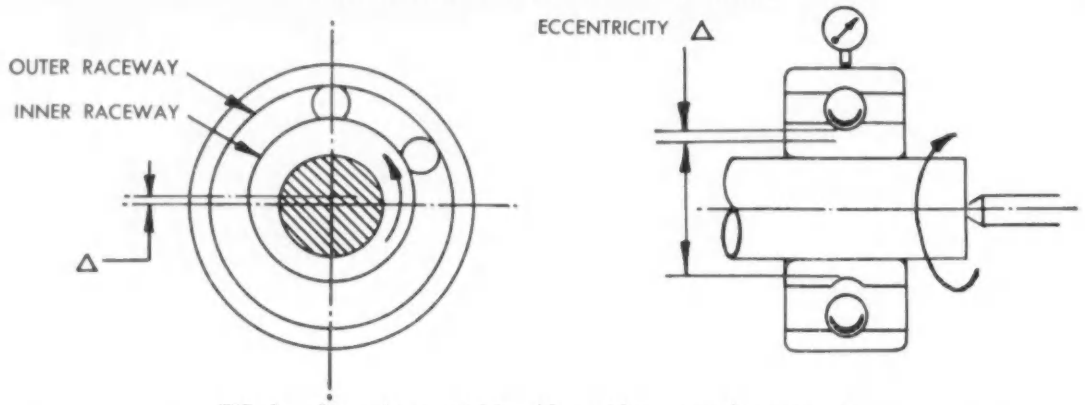

FIG. 1 — *Measuring eccentricity of bore with respect to inner raceway.*

Occasionally questions are raised about the methods of measuring "radial runout" and "out-of-round". In order to define "radial runout" properly, a discussion of "eccentricity" and "out-of-round" is necessary.

The amount of out-of-round, or lack of roundness of a given part (inner or outer ring or ball) is the difference between the maximum and the minimum diameter of the part in question.

Eccentricity refers to the distance between the centers of two circles. Concentricity refers to the exact coincidence of the centers of two or more circles. In high grade instrument bearings there is a very small tolerance on the permissible eccentricity between the bore and the inner ring raceway, and likewise between the outside diameter and the outer ring raceway.

Inner raceway out-of-round is measured by forcing the ring between the rounded edges of two discs, one of which is fixed and the other of which is mounted on the indicating mechanism. The difference between the maximum and minimum readings reveals the amount of out-of-round. Out-of-round of the outer ring raceway is measured by placing the ring over two rounded points which engage the raceway. One point is fixed and the other actuates an indicating mechanism. As the ring is rotated, the difference between the maximum and minimum readings indicates the degree of out-of-round.

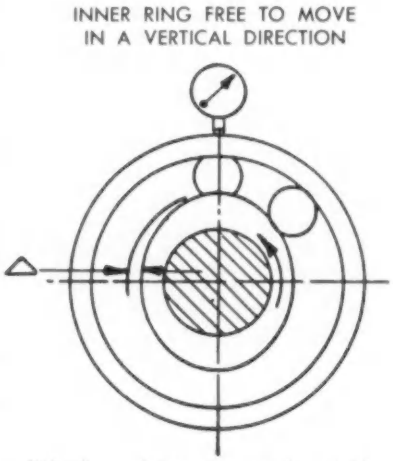

FIG. 2 — *Inner raceway is out-of-round, although concentric with bore.*

The true amount of eccentricity between the bore and the inner ring raceway can be measured, providing these circles are not out-of-round, by mounting the assembled bearing on a slightly tapered arbor, applying a calibrated indicator on the center of the stationary outer ring, and then slowly rotating the arbor. The eccentricity is the difference between the minimum and maximum gage reading as the arbor is rotated through one revolution. Similarly, the eccentricity of the outer ring is measured by the difference in the dial readings with the arbor and inner ring held stationary while the outer ring is rotated one revolution. *Fig. 1* shows the set-up with an inner raceway which is eccentric with respect to the bore.

In the case above it has been stipulated that the bore and inner raceway must not be out-of-round, for only under these conditions is the true eccentricity measured.

If the raceway is out-of-round, while being either eccentric or concentric with respect to the bore, the out-of-round will be transmitted to the indicator, thereby influencing the reading. A condition in which the inner raceway is out-of-round although concentric is shown in *Fig. 2*.

In view of the fact that the majority of bearing rings will unavoidably be somewhat out-of-round and eccentric, however slightly, it is obvious that the measurement described above indicates neither true eccentricity nor true out-of-round but a summation of the two quantities. Hence the measurement is more correctly termed *radial runout*.

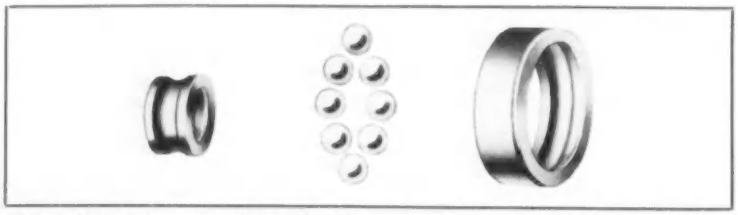

FIG. 3 *Radial Runout is the result of eccentricity in the bearing parts. Principal factors producing it are eccentricity between bore and raceway of inner ring (left) and between raceway and outer diameter of outer ring (right). Out-of-round balls offer negligible effect, since effect tends to cancel out as balls roll.*

DESIGNERS HANDBOOK OFFERED *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

It will be sent free to engineers, draftsmen and purchasing agents.

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 352.

Zinc Coating–Brochure, 4 pp. Contains data on ready mixed coating for stoppage of rust and rust creepage. Sealube Co., Wakefield, Mass.
Circle 105, inside back cover

Heavy Duty Series–Parallel Switches, Brochure, 2pp. Contains diagrams and data on 12-24 v switches for engines having 12 v system. Leece-Neville Co., Cleveland 3, Ohio.
Circle 106, inside back cover

Lockwashers–Brochure, 4 pp. Contains data on stamped spring steel units formed from flat strip stock. Pioneer Stamped Products Co., P. O. Box 185, Brighton Station, Rochester 10, N. Y.
Circle 107, inside back cover

Hollow Aluminum Bar Stock–Brochure, 8 pp. Contains data and tables on tolerances, mechanical properties, and applications of tubing. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.
Circle 108, inside back cover

Pump Troubles–Bulletin PC 508, 4 pp. Cartoons picture problems evolving from rotary, centrifugal and steam pumps. Worthington Corp., Harrison, N. J.
Circle 109, inside back cover

Air and Water-Cooled Compressor Troubles–Bulletin PC 509, 4 pp. Cartoon sequence pictures a description of compressor problems. Worthington Corp., Harrison, N. J.
Circle 110, inside back cover

Irradiated Polyethylene–Booklet, 12 pp. Describes moisture and chemical resistance, encapsulation ability and thermal stability, typical applications and techniques of use. General Electric Co., Plastics Ave., Pittsfield, Mass.
Circle 111, inside back cover

Tubing System Data–Booklet 4305, 8 pp. Contains information charts and tables to aid in proper selection of tubing. Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.
Circle 112, inside back cover

Conveyor Pulleys–Catalog CP-80, 12 pp. Contains specifications and prices. R. & J. Dick Co., Inc., 1 Sade St., Passaic, N. J.
Circle 113, inside back cover

Truck Casters and Wheels–Catalog K40, 68 pp. Contains information and pictures of casters, wheels and accessories. Bond Foundry & Machine Co., Manheim, Pa.
Circle 114, inside back cover

Power Transmission Machinery–Catalog D56, 328 pp. Contains charts, diagrams and pictures on bearings, clutches, pulleys, speed reducers. Dodge Mfg. Corp., Mishawaka, Ind.
Circle 115, inside back cover

Retaining Rings–Catalog, 11 pp. Contains data on open-type rings for shafts measuring 1/25 to 1 in., internal rings for housings measuring ¼ to 2 1/16 in. and external rings, to fit shafts from ⅛ to 2¼ in. Dept. P 23, Industrial Retaining Ring Co., 57 Cordier St., Irvington 11, N. J.
Circle 116, inside back cover

Repulsion-Induction Motors–Bulletin SDA 163 A, 2 pp. Contains data on single phase motor produced in sizes from ¾ to 7-½ hp; 1150 to 1750 rpm; 60-50 cycles. Peerless Electric Co., Market St., Warren, Ohio.
Circle 117, inside back cover

D-c Motors–Bulletin, 6 pp. Contains data on ½ through 200 hp motors and motor-generator sets up through 200-kw output. Allis-Chalmers Mfg. Co., 1002 70 St., Milwaukee, Wis.
Circle 118, inside back cover

Polyethylene Pipe–Bulletin CE-57, 8 pp. Contains data on applications, sizes, technical properties, and estimated flow rates for water in various

(Continued on page 342)

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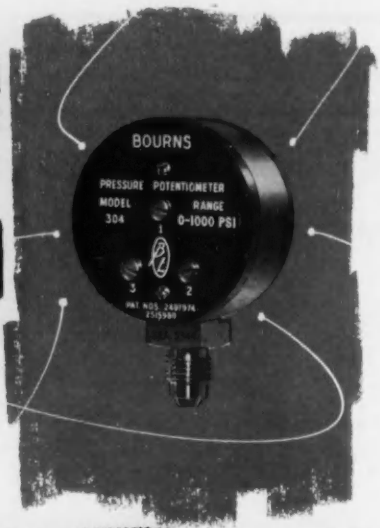

MODEL 304

GAGE PRESSURE TRANSDUCER

—high performance in miniature size

Only 1⅝" in diameter... ¾" thick, this is an exceptionally small gage pressure potentiometer. Its miniature size and compact configuration permits use in ground and airborne installations—in control telemetering or remote recording circuits—wherever space is at a premium.

Time proved performance. This is a fully integrated instrument built for high reliability under extreme environmental conditions. The dependable Bourns Bourdon tube assembly and linkage system provide exceptional shock, vibration and acceleration characteristics ... linearity and hysteresis are excellent. Units are designed to meet or exceed most government specifications for airborne equipment.

The Bourns Model 304 weighs about 2 ounces. It operates with a high-level AC or DC signal. Pressure ranges: from 0-100 to 0-5000 psi. Three Bourdon tube materials are available:

Beryllium copper—the standard construction—for non-corrosive fluids. Measures air, Freon, oil, and other common media.

Stainless steel—permits corrosive fluids such as fuming nitric acid to be applied within the tube.

Ni-Span-C—provides low temperature error for versatility of application.

Complete data in Bulletin No. 304.

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In addition to the Model 304, Bourns manufactures a complete line of high pressure transducers in absolute and differential ranges, for use with corrosive or non-corrosive fluids. Request Bulletin No. 70456.

MODEL 704—differential pressure type with stainless steel Bourdon tube

MODEL 706—differential pressure type with Beryllium copper Bourdon tube

MODEL 705—absolute pressure type for use with clean, non-corrosive media

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pipe sizes. American Hard Rubber Co., 93 Worth St., New York 13, N. Y.

Circle 119, inside back cover

Constant Voltage D-c Power Supplies—Booklet DC 235, 8 pp. Contains data for six, standard-design, regulated d-c power supplies for intermittent, variable, pulse loads, or high-amperage loads. Sola Electric Co., 4633 West 16 St., Chicago 50, Ill.

Circle 120, inside back cover

Lithium Compounds—Folder, 38 pp. Contains data on chemical and physical properties. Foote Mineral Co., 18 W. Chelten Ave., Philadelphia 44, Pa.

Circle 121, inside back cover

Precision Balls—Brochure, 4 pp. Contains information on balls made from many materials. Universal Ball Co., Willow Grove, Pa.

Circle 122, inside back cover

Thermistor Overheat Detectors—Bulletin, 3 pp. Discusses advantages of thermistor elements for temperature detection. Fenwal Inc., Ashland, Mass.

Circle 123, inside back cover

Dollar Savings through Standards—Booklet, 40 pp. Contains economic benefits to industry resulting from use of standards. American Standards Assn., Inc., 70 E. 45th St., New York 17, N. Y.

Circle 124, inside back cover

Distribution Systems for Automatic Lubricators—Bulletin 4A, 12 pp. Contains data and diagrams on reservoirs, tubing, fittings, junctions and meter-units. Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.

Circle 125, inside back cover

Potentiometers and Accelerometers—Bulletins (2), 2 pp, contains data and diagrams. Humphrey Inc., 2805 Canon St., San Diego 6, Calif.

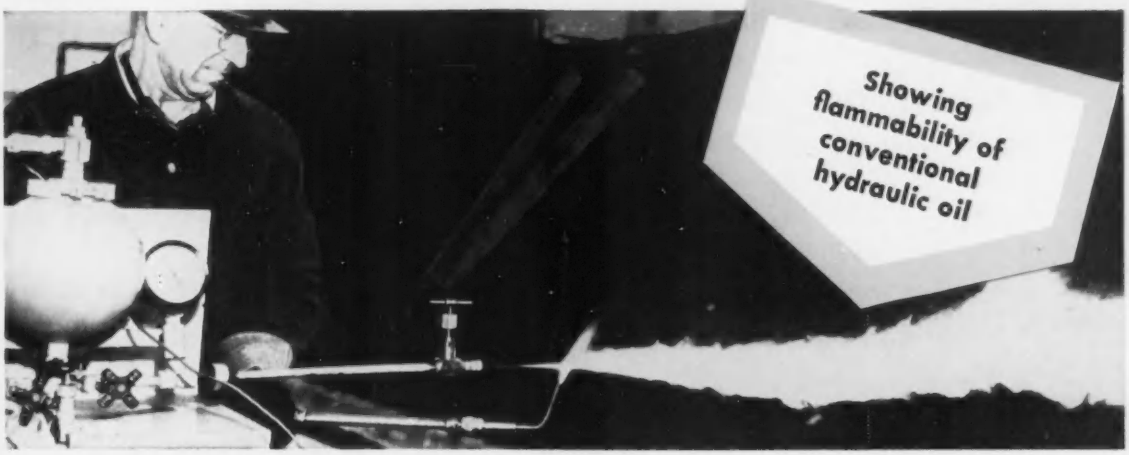
Circle 126, inside back cover

Contacts and Rivets—Catalog, 4 pp. Describes 300 standard electrical contacts. Deringer Metallurgical Corp., 8131 Monticello Ave., Skokie, Ill.

Circle 127, inside back cover

Motors—Bulletin GED 2020B, 16 pp. Contains information on how

(Continued on page 344)



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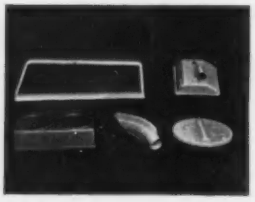

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to choose the correct fhp motor for farm, home, and shop jobs. General Electric Co., Schenectady 5, N. Y.
Circle 128, inside back cover

Delivery Date Calculator–Dial produced on heavy-weight varnished board determines future delivery date. Nooter Corp., 1420 S. Second St., St. Louis, Mo.
Circle 129, inside back cover

Speed Reducers–Bulletin 98, 4 pp. Describes reducer with maximum power output of 0.1 hp. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.
Circle 130, inside back cover

Automatic Clutches and Transmissions–Bulletin 56D1,4 pp. Contains data and diagrams to assist in selection. Salsbury Corp., 1161 E. Florence Ave., Los Angeles 1, Calif.
Circle 131, inside back cover

Tool Steel Handbook–Hardbacked book, 204 pp. Has chapters on selecting the proper steel, tool steel products, and working tool and high speed steels. Allegheny Ludlum Steel Corp. 2020 Oliver Bldg., Pittsburgh 22, Pa.
Circle 132, inside back cover

Time Controls–Booklet, 20 pp. Contains information, pictures and chart on industrial time controls. Paragon Electric Co., Two Rivers, Wis.
Circle 133, inside back cover

Speed Reducers–Booklet B 6727, 45 pp. Contains data and charts on hp ratings, torque capacity, overhung load values and dimensions. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.
Circle 134, inside back cover

Thermistor-Actuated Temperature Controller–Bulletin MC 133, 4 pp. Contains data on an individual unit which is plugged into a separate power supply chassis. Fenwal Inc., Ashland, Mass.
Circle 135, inside back cover

Linear and Angular Micro-Positioning Systems–Bulletin 819, 12 pp. Contains data on an electronic automatic machine tool control capable of automatically positioning the carriage of a machine tool with a maximum linear error of 0.0001 in. or

(Continued on page 348)

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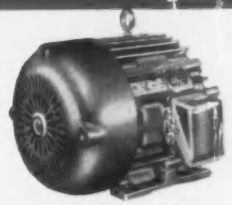

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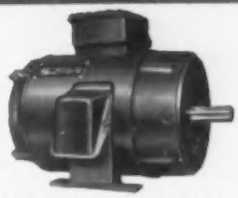

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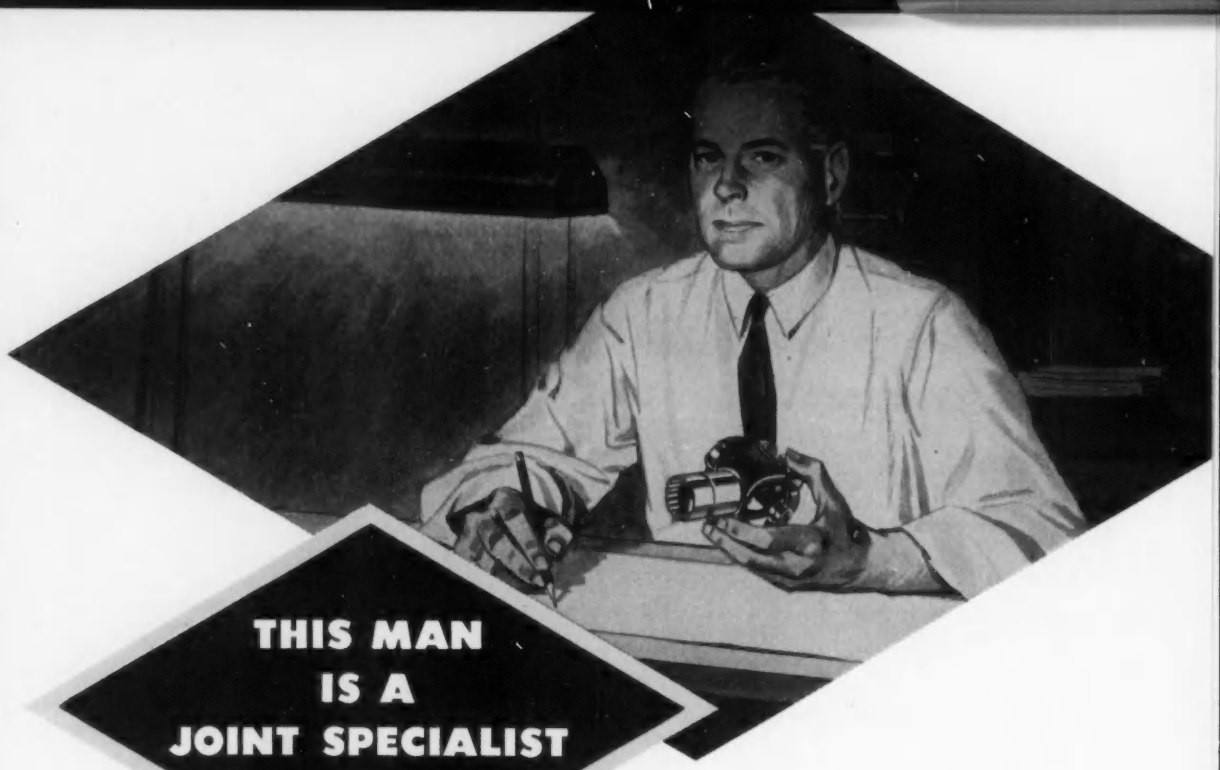

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positioning a rotational member with a maximum angular error of 5 sec of arc. Farrand Controls, Inc. 4401 Bronx Blvd., New York 70, N. Y.
Circle 136, inside back cover

Detachable Couplers–Bulletin, 15 pp. Contains specifications and diagrams on couplers, fittings, adapters and connections. Foster Mfg. Co., Inc., 2850 Gravois, St. Louis 18, Mo.
Circle 137, inside back cover

Straight Line Thrust Mechanisms–Bulletin GEA 1614D, 8 pp. Contains data on productivity, benefits and describes applications. General Electric Co., Schenectady 5, N. Y.
Circle 138, inside back cover

Miniature Electrical Connectors–Catalog, 8 pp. Describes standard plugs and receptacles as well as push-pull miniature connectors and spherical orientation (rack and panel) connectors. Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.
Circle 139, inside back cover

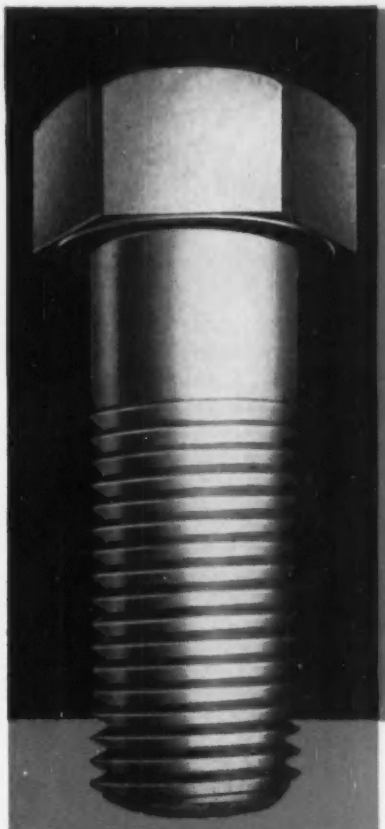
Precision Radial Roller Bearings–Catalog PR 456 DC, 58 pp. Contains diagrams and data on selection, load ratings and applications. Rollway Bearing Co., Inc., 541 Seymour St., Syracuse, N. Y.
Circle 140, inside back cover

Bolts, Nuts, Screws, Rivets and Washers–Catalog, 130 pp. Contains diagrams, information and charts on assorted metal fasteners. Sterling Bolt Co., Chicago 10, Ill.
Circle 141, inside back cover

Control and Data Processing Instruments–Bulletin, 31 pp. Contains information, pictures on charts. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.
Circle 142, inside back cover

Flexible Plastic Tubing–Bulletin T-97, 28 pp. Contains applications, limitations, physical properties and chemical resistances. U. S. Stoneware Co., Akron 9, Ohio.
Circle 143, inside back cover

Safety Devices for Steam and Hot Water–Catalog, 8 pp. Contains data and price list on cutoffs, pump
(Continued on page 350)



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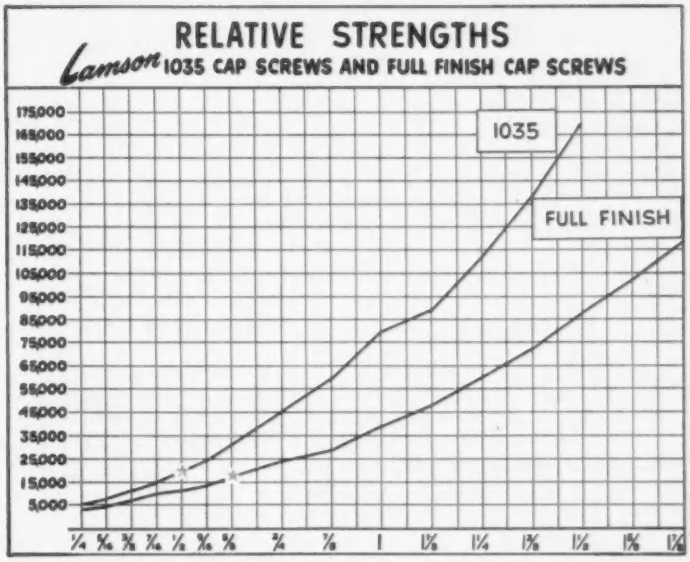

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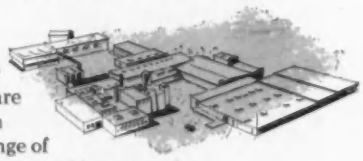

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Catalogs and Bulletins.....continued

controllers, relief valves, flow switches. McDonnell & Miller, Inc., 3500 N. Spaulding Ave., Chicago 18, Ill.

Circle 144, inside back cover

Vane-Actuated Switch—Brochure S800-1, 2 pp. Describes and illustrates control unit. Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Circle 145, inside back cover

Plastic Engineering Materials—Booklet, 17 pp. Contains data and comparative characteristics chart on Teflon, Zytel, Alathon and Lucite. E. I. DuPont De Nemours & Co., Inc., Wilmington 98, Del.

Circle 146, inside back cover

Temperature Controls—Catalog, 6 pp. Contains physical specifications, performance data, and temperature ranges. Fenwal Inc., Ashland, Mass.

Circle 147, inside back cover

Full Flow Valves—Bulletin 500, 4 pp. Contains data and diagrams on design and function. Coppus Engineering Corp., Worchester 2, Mass.

Circle 148, inside back cover

Formulated Epoxy Resins—Chart gives physical and electrical data on 27 resin systems. Furane Plastics Inc., 4516 Brazil St., Los Angeles 39, Calif.

Circle 149, inside back cover

Forgings and Castings—Catalog, 30 pp. Contains data on smooth hammered forgings, composite die sections and cast-to-shape tool steels. Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.

Circle 150, inside back cover

Metals and Alloys For Tubing—Brochure 1, 3 pp. Lists 121 metals and alloys from which the firm produces its standard and special small diameter tubing. Superior Tube Co., 1556 Germantown Ave., Norristown, Pa.

Circle 151, inside back cover

Rotary Blowers—Brochure, 5 pp. Contains data and charts. Miehle-Dexter Supercharger, 100 4 St., Racine, Wis.

Circle 152, inside back cover

Pressure Tubing—Bulletin 22, 3 pp. Describes tubing designed for safe

(Continued on page 352)

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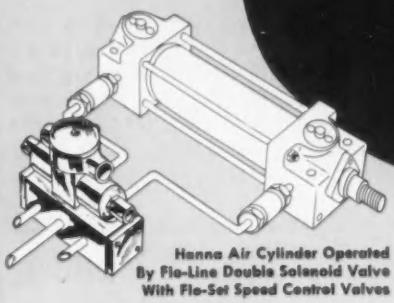

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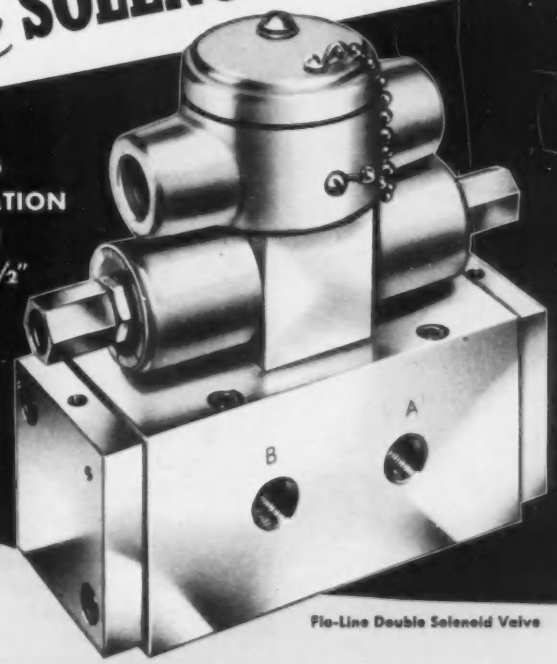

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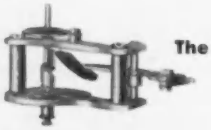

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Catalogs and Bulletins.....continued

service at pressures up to 100,000 psi. Superior Tube Co., 1556 Germantown Ave., Norristown, Pa.

Circle 153, inside back cover

Flow Controls—Catalog 553, 8 pp. Contains data and drawings of basic hydraulic restrictor and needle valves and adjustable, pressure compensated flow regulators. Fluid Controls, Inc., 1284 North Center St., Mentor, Ohio.

Circle 154, inside back cover

Wirerope—Catalog, 188 pp. Tables, data and specifications on wirerope, assemblies and cables. Macwhyte Co., Kenosha, Wis.

Circle 155, inside back cover

Plastic Tooling—Brochure, 8 pp. Contains data on the applications of plastic tooling for metal-forming and plastics-forming and in foundry practice. Marblette Corp., 37-31 Thirtieth St., Long Island City 1, N. Y.

Circle 156, inside back cover

Silver-Cadmium Exide Electrical Contacts—Bulletin, 4 pp. Contains information and tables. H. A. Wilson Co., 2655 U. S. Route 22, Union, N. J.

Circle 157, inside back cover

Electric Welded Mechanical Steel Tubing—Bulletin MST-856, 3 pp. Contains data, chart and applications of tubing size $\frac{3}{8}$ in. O.D. to $2\frac{3}{4}$ in. O.D. Walker Brothers, Conshohocken, Pa.

Circle 158, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Electronics Facts Handbook—Booklet, 20 pp. A collection of selected reference data useful to people concerned with government and industrial research and development activities. American Machine & Foundry Co., 261 Madison Ave., New York 16, N. Y.

Brass, Bronze and Aluminum Forgings—Booklet, 32 pp. Contains information on design, properties and application. Dept. R, Titan Metal Mfg. Co., Bellefonte, Pa.

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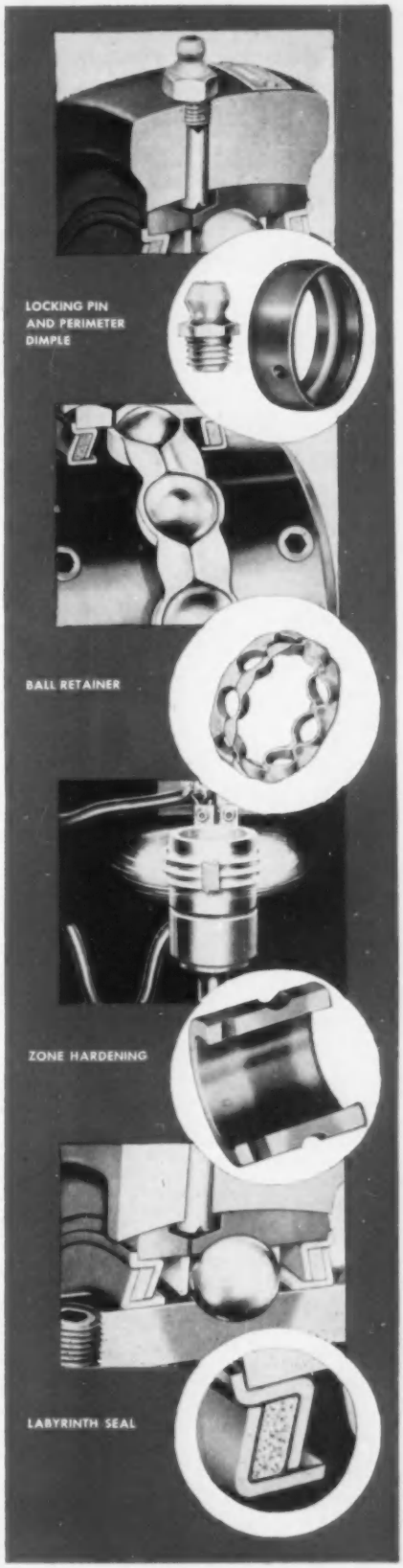

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Pictured, Cramer Hi-Model 4D-22T with forward-tilt seat; others available. All are low-gravity balanced for safe use on casters if desired.

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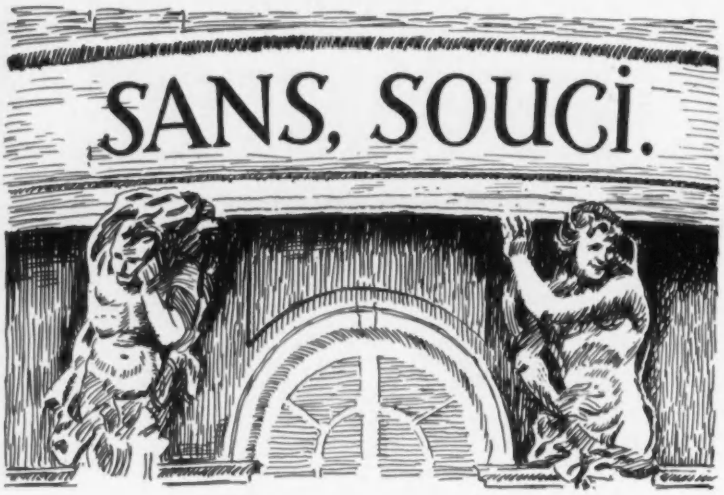
Cramer Posture Chair Co., Inc., Dept. E
1205 Charlotte, Kansas City 6, Mo.

Please send me complete facts on the Cramer Hi-Model chairs designed for working architects and engineers.

Name _____

Firm _____

Address _____



Ad Libbing by The Editor

During my years at Lehigh University, and for many years afterward, there was a man on the faculty whom we called "Bosey" Reiter. Bosey, a Princeton man, came to Lehigh as football coach and in a few years became professor of physical education. Beloved by both faculty members and students, Bosey left a record that few can match. He was a wonderful leader, a man who inspired, an orator, and possessor of that rare combination of good fellowship and dignity. He had deeply creased features that bespoke stern determination. He never used words that were not fit for ladies and children to hear.

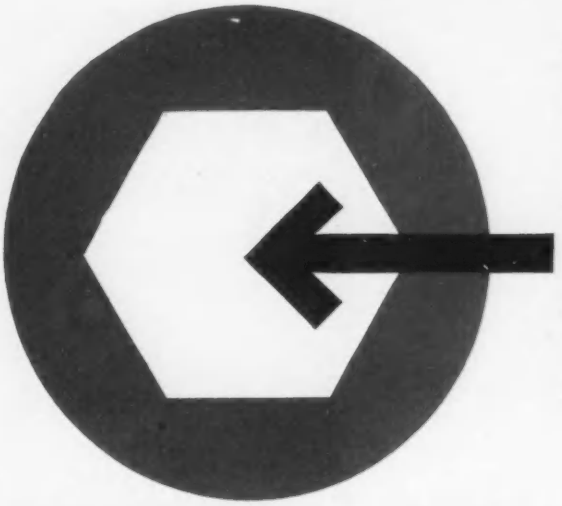
It is not surpising that Bosey had a tremendous influence over the students. His oratory was of the "fighting kind." His kind of stories and poetry thrilled many audiences. And many Lehigh football teams were inspired to outdo themselves and come out victorious even with the odds all against them. And if they lost, Bosey would quote Grantland Rice's famous words, "When the one Great Scorer comes to mark against your name, He writes not won, or lost, but how you played the game." There have been other great inspirational leaders in my life, but there has been only one Bosey.

I have often contemplated the parts played by great leaders in inspiring people to outdo themselves, to suffer for a cause, to be martyrs. All such leaders have had one thing in common. All of them were highly respected for among other things, their knowledge and confidence. They knew the field in which they led. They had risen to their position of leadership by virtue of the fund of knowledge and experience they had accumulated and the respect or fear they commanded.

Some inspirational leaders did much harm. Hitler inspired a whole nation to plunge much of the world into a decade of misery. It was about 1936 that Herbert Hoover made a trip through Europe. After his return he was asked what he thought about Hitler, whose guest he had been for several days at Berchtesgarten. Hoover's answer was about like this—"I met many of the most brilliant men of Europe but none was more brilliant than Hitler. After I had been at Berchtesgarten for a day or two I got the courage to say to Hitler, 'People say you are crazy.' Hitler's eyes blazed and he looked hard at me, and said, 'Mr. Hoover, I know that is said of me, but I assure you that I am not crazy. I am a fanatic, a terrible fanatic, but I am not crazy.'" Hoover then added, "I am sure that what Hitler said of himself is true; and that man will some day soon bring great sorrow and trouble to this world."

Ironically, when we hear the word leadership we usually think of leadership in the military, political, business or sports field. Actually the world's greatest and most fruitful leadership has been, and always will be, in the field of religion. And the second most fruitful field for leadership is education. Education and religion together are the greatest builders of good leadership. Every person can look back

(Continued on page 356)



STRAIGHT FACTS ABOUT HOLO-KROME SOCKET SCREWS

30 seconds to separate fact from fancy!

FACT 1 Holo-Krome Socket Screws are far tougher than you might think. Their sockets easily withstand at least 50% more torque than can be exerted by a hex key in ordinary hand-tightening.

FACT 2 Power tool tightening is different. Then tightening force depends on the torque of the driving tool, strength of the bit, and the inherent toughness of the socket. H-K sockets are guaranteed to give unfailing performance.

FACT 3 Holo-Krome sockets have sharp hex corners, untapered socket walls, socket depth scientifically proportioned, continuous metal fibers reinforcing the socket wall.

Your best insurance against socket screw failure is H-K's exclusive forging method. For the toughest in socket screws—and hex keys—look to Holo-Krome!

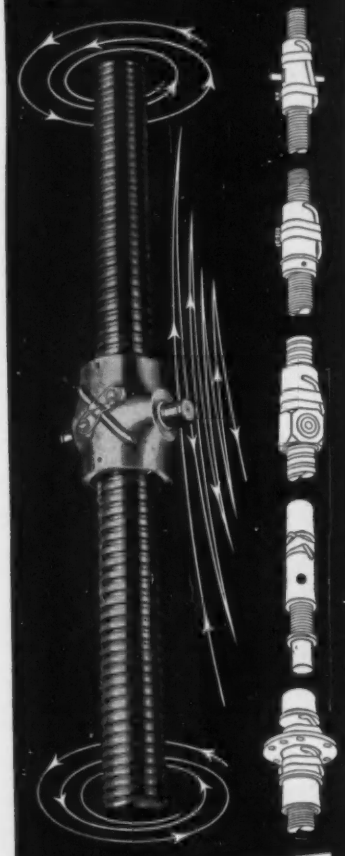
HOLO-KROME

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

beaver ball screws

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficiency in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments to massive wind tunnel jacks. Any diameter or travel: indexing, inching, traversing. Literature, consulting engineering service available.



Fastest growing source for ball screws

Beaver Precision Products INC.
CLAWSON, MICH.

upon teachers who influenced them greatly and put them on the right track.

"King" Dean was a high school math teacher. He was very demanding, strict and a hard marker. The students used to say that King Dean had such reverence for perfection that he never gave a mark of 100 percent. But all the students loved him.

"Thorny" was the secretary of a college faculty. His code was inflexible. A student either made passing grades or he was "flunked out." He dominated the faculty but was not domineering. He was always exactingly just. No student ever claimed that "Thorny" had been unfair to him. Many a student whom "Thorny" had flunked out, loudly sang his praises for many years afterward.

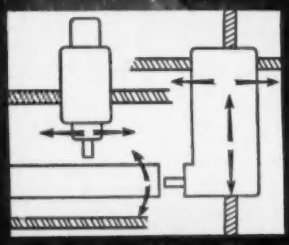
There is always room for more and better leadership in every organization and in every engineering department. It is the essential ingredient without which there can be no progress. The ingredients of such leadership must develop enthusiasm and self confidence and determination as did Bosey Reiter, and yet that leadership must be strict and demanding, as was "King" Dean, and sternly just as was Thorny. And there are many more ingredients which contribute to inspirational leadership. It is the basis for all progress and thereby a yardstick of prosperity. No business or department organization can grow and thrive if its directing head does not exert inspiring leadership.

If we dig into the past history of almost any company we find a lot of romance and a lot of drama. One of the early great men of Bethlehem Steel was John Fritz whose business learning began in a blacksmith's shop and ended in the steel works. It was he who built the Bethlehem Iron Works back in the days before the Civil War, in 1860 to be exact. He was regarded the father of the steel industry. He and Asa Packer, the coal and iron "Baron" of Pennsylvania, were close friends. Both of these men had come up the hard way, especially John Fritz who later helped Asa Packer establish the second technical school in the United States. Rensselaer Polytechnic Institute was the first and Lehigh University was the second.

John Fritz was tremendously inter-

(Continued on page 360)

The same mechanism that controls the horizontal tail may improve your machine tool



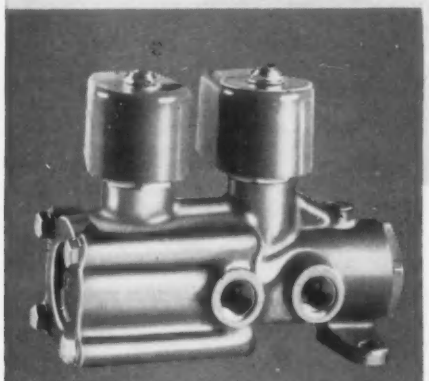
The G. & L. and Hypro Div. of the Giddings & Lewis Machine Tool Co. uses 4 Beaver Ball screws (up to 16' long) per machine for automatically positioning heads and swiveling the work chuck of their numerically controlled skin mills—shown here machining wing skin for a jet fighter aircraft.

Our engineers are available to discuss machine design problems with you.

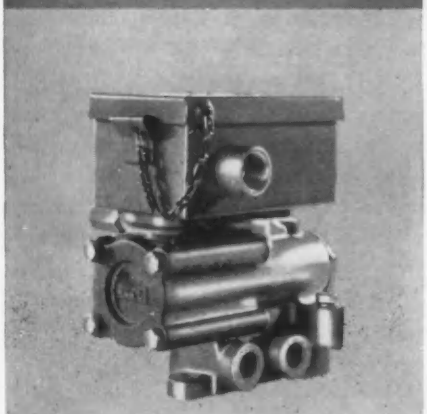
Beaver Precision Products INC.
CLAWSON, MICH.

Now available: full line of ASCO 4-way solenoid valves

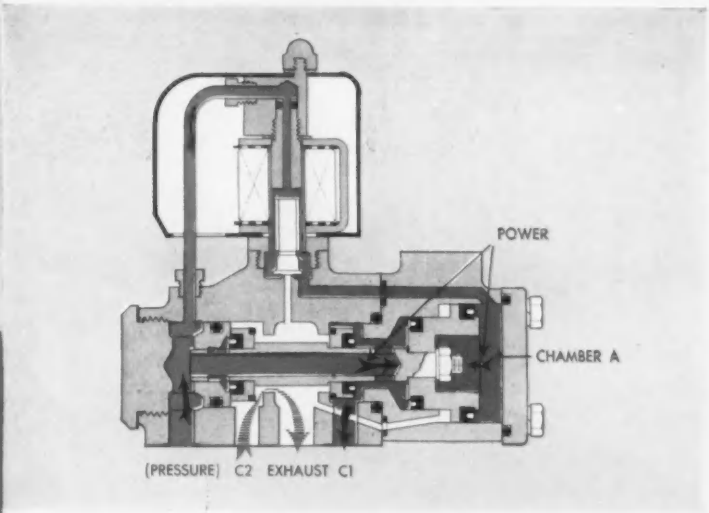
Single Solenoid: operates when solenoid is energized; returns automatically when de-energized.



Dual Solenoid: operates when either solenoid is energized; will not return until opposite solenoid is energized. Solenoids may be energized continuously or momentarily.



J.I.C. Construction: single and dual solenoids, with sub-plate mounting.



power driven in both directions by line pressure

Now available in ⅜" through 1" sizes, these valves are positive in action. When the solenoid is de-energized, *line pressure* applied to the top of the pilot core forces it off the seat, eliminating possible sticking caused by residual magnetism. *Line pressure* is applied to Chamber A, moving the piston-disc assembly to the left. When the solenoid is energized, Chamber A is exhausted and *line pressure* drives the piston to the right.

absolutely tight seating — no leakage

Combination of metal to metal and resilient seating provides dead tight shut-off – even on air. No grinding, lapping or close adjustments are necessary.

Available in standard, watertight or explosion-proof solenoid enclosures, the Bulletin 8344 permits cycling rates to 850 per minute – mounted in any position. Design simplicity eliminates maintenance problems.

J.I.C. construction available

These 4 way valves are available in all sizes to meet J.I.C. (Joint Industry Conference) standards. Valves are provided with sub-plates, vapor-proof solenoid enclosures, and manual overrides, and are electrically inoperative when the cover is removed.

New ASCO Condensed Valve Catalog No. 201 is now available. Write today for this basic reference on solenoid valves.

Important announcement . . . *new ASCO plant now being built in Florham Park, N. J., will double production capacity and greatly extend the range of our research, product development and services.*

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SOLENOID VALVES ELECTROMAGNETIC CONTROL

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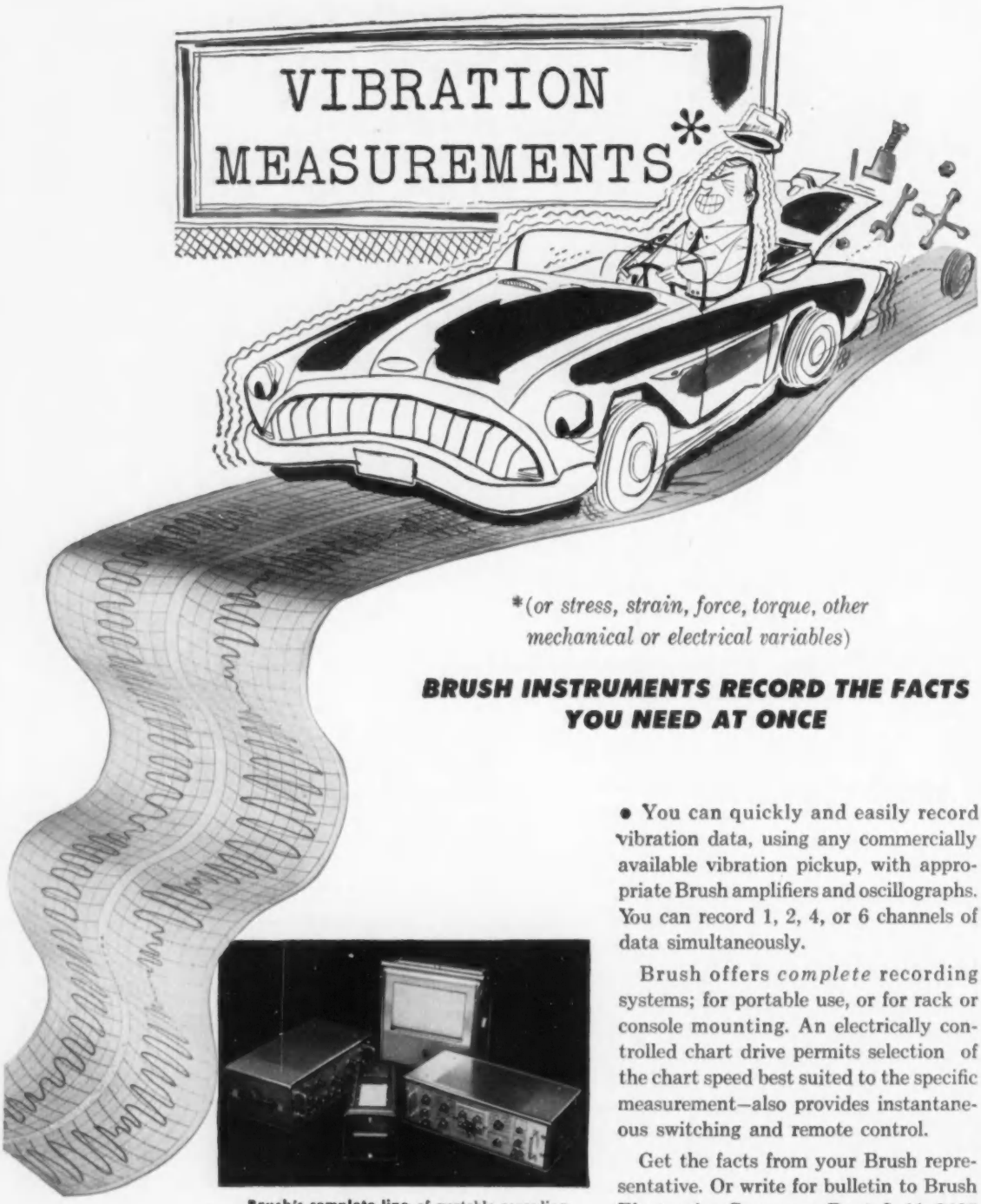
ASCO

VIBRATION MEASUREMENTS*



*(*or stress, strain, force, torque, other mechanical or electrical variables*)

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Brush's complete line of portable recording systems includes these portable amplifiers, and 1, 2, 4, and 6 channel oscillographs.

• You can quickly and easily record vibration data, using any commercially available vibration pickup, with appropriate Brush amplifiers and oscillographs. You can record 1, 2, 4, or 6 channels of data simultaneously.

Brush offers *complete* recording systems; for portable use, or for rack or console mounting. An electrically controlled chart drive permits selection of the chart speed best suited to the specific measurement—also provides instantaneous switching and remote control.

Get the facts from your Brush representative. Or write for bulletin to Brush Electronics Company, Dept. L-11, 3405 Perkins Avenue, Cleveland 14, Ohio.

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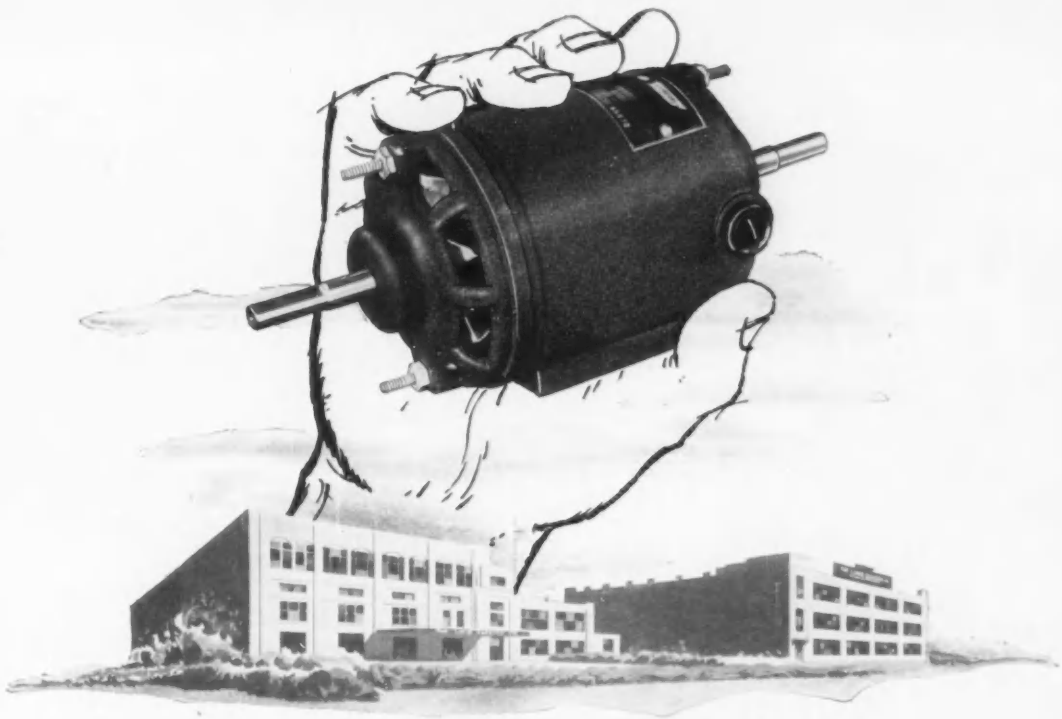

CUSTOM-BUILT USE-ABILITY...

for your motor-driven products

Exceptional performance and dependability go with useability in Lamb Electric Motors because they are:

(1) "tailored" to the exact requirements of an application.

(2) built of quality materials by precision-minded personnel.

Our company is equipped and organized to *custom-manufacture on a volume basis;* hence high quality and controlled costs go hand-in-hand.

We would like to discuss these advantages with you for *your* new and redesigned products.

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Swivel-mounted portable tool motor.

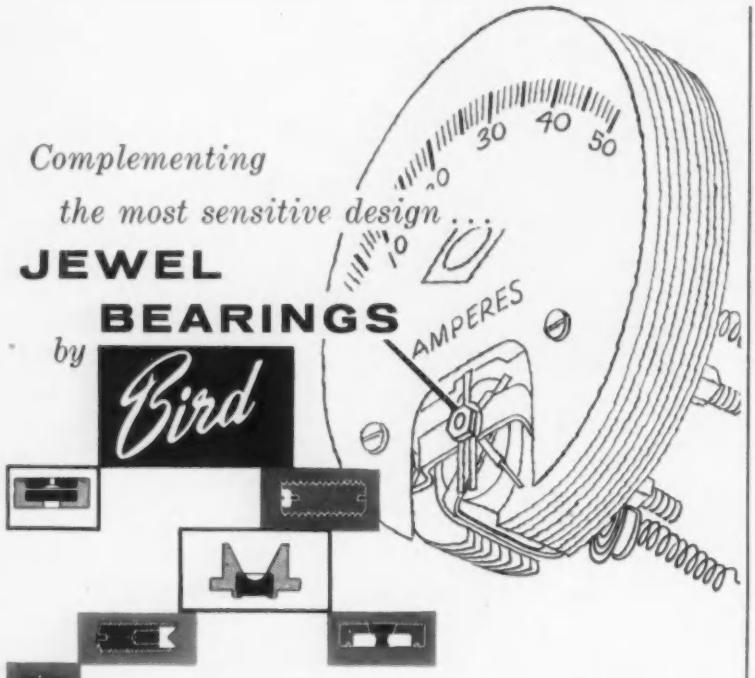
Aircraft de-icing pump motor.

Gear motor for slow-speed drive.

Turbine for canister-type vacuum cleaner.

If you are interested in any of the motors at left write and we shall be glad to send full information.

Complementing
the most sensitive design . . .
JEWEL BEARINGS
by Bird



No matter how exacting the conditions,
Bird **JEWEL BEARINGS ASSEMBLE MORE READILY and FUNCTION MORE EFFICIENTLY.**

A variety of settings and mounts, plus a wide range of sizes (stock sizes, or to specification), enables these high-precision elements to be ideally incorporated.

In addition, various settings and cushioning methods — silicon rubber, spring, or friction settings — provide maximum protection for bearings subject to severe shock conditions, yet permit controlled jewel movement, thus ending lost time for tear-down and readjustment.

Of particular advantage are the complete jewel assemblies, set in screws or bushings, which Bird provides in standard sizes or to your specifications. These assemblies greatly reduce overall cost by eliminating rejects, stopping waste, and cutting assembly time. Prove these advantages in your own plant. Forward a print to us with specifications — we'll provide you with testing samples.

For information on Bird Jewels write for Bulletin 14

Stringent quality control methods, exact tolerances and design features insure

- ✓ LASTING PRECISION PERFORMANCE
- ✓ LONGER INSTRUMENT LIFE
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Over 40 years of serving Industry with Quality Jewel Bearings

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SAPPHIRE AND GLASS JEWELS, PRECISION GLASS GRINDING, JEWEL MOUNTING AND ASSEMBLY, SAPPHIRE STYLI
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ested in Lehigh University and was one of the original trustees, serving on the Board of Trustees from 1866 to 1895. He gave to Lehigh University the finest engineering materials-testing laboratory of the times. Typical of John Fritz, he himself supervised the drawing of the plans and during the building of the testing laboratory spent much of his time supervising its construction. Indeed, back in 1911 or '12, the students would often see old John Fritz sitting on a chair underneath a beach umbrella, out in the rain, watching the Fritz Engineering Laboratory building being constructed.

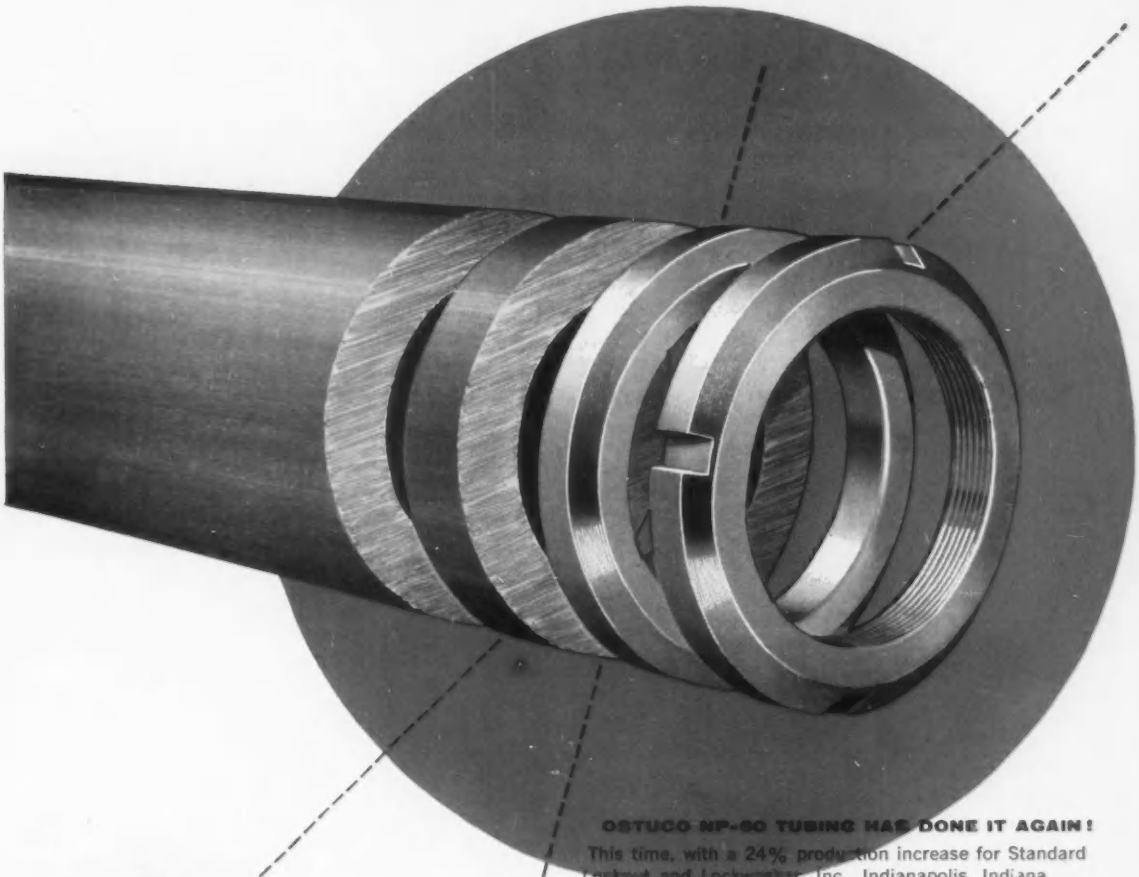
At the time it was first built the Riehle tensile testing machine installed at Lehigh had a capacity of 800,000 pounds. It was about the biggest of its days but was later superseded in size by machines installed at the National Bureau of Standards and elsewhere. It is quite fitting that last year a big addition was built to the Fritz Engineering Laboratory and there was installed a 5,000,000 pound universal testing machine, the biggest of its kind. It is also quite fitting that this testing machine, designed and built by Baldwin-Lima-Hamilton Corporation, was contributed by Bethlehem Steel Company in cooperation with Lehigh University. **–G.F.N.**

Colored Finishes For Copper

Copper is the only metal (except gold) having a rich natural color; all other metals are some shade of gray. Also, natural finishes on copper and copper-base alloys offer an unusual range of attractive surfaces, either in the metal itself or through mechanical or chemical treatment of the surface.

An 8-page special insert in full color in the December issue will discuss and illustrate these natural finishes, the effect of alloy content and coloring treatment and mill produced surfaces. The article, authored by A. L. Heim, research engineer of Copper & Brass Research Association, will include specifications for a variety of coloring and surface treatment procedures.

Typical examples will be shown in natural color with detailed data on finishing systems used for each.



24% Production increase at Standard Locknut & Lockwasher, Inc. after switching to OSTUCO NP-60 tubing

OSTUCO NP-60 TUBING HAS DONE IT AGAIN!

This time, with a 24% production increase for Standard Locknut and Lockwasher, Inc., Indianapolis, Indiana. Tubing experts from OSTUCO recently recommended a switch to NP-60 Tubing specially processed for machineability for Standard's locknut and lockwasher line used in ball and roller bearing applications.

Standard components find their way into electric motors, machine tools, automotive, aircraft, farm and construction equipment. Other companies, with equally diverse applications, report similar success with NP-60. If you are machining bearings, washers, collars, or any circular part, you'll do well to check into the merits of OSTUCO's new NP-60 seamless steel tubing.

GET NP-60 WITH "SINGLE-SOURCE SERVICE."

New NP-60 seamless tubing comes to you with OSTUCO'S unique "Single-Source Service"—experience and facilities for design and development, production and delivery all under one roof. Get together with a tubing expert for preliminary planning on NP-60's possibilities in your product. Contact your nearest sales office or write direct to the factory.

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★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components

NEW! MINIATURE RESISTOR for MINIATURE EQUIPMENT

New Ward Leonard 3-watt wirewound fills need for high-stability, space-saving power resistor

NEW WARD LEONARD TYPE 3X Resistor

A 3-watt wirewound with the compactness of an ordinary ½-watt composition resistor—that's what Ward Leonard's new Type 3X Axiohm resistor gives you!

This new resistor now makes it practical to specify a wirewound resistor for your transistorized, printed-circuit, or other miniaturized designs. You get the wirewound resistor's drift-free stability, low voltage coefficient, and high overload capacity in a tiny package.

Type 3X Axiohms, like larger Ward Leonard Axiohm resistors, are wound with special alloy resistance wire on tough miniature ceramic cores. Temperature coefficient of resistance is exceptionally low.

Resistance wire and axial leads are spot-welded to end caps, insuring a strong, permanent, low-resistance bond.

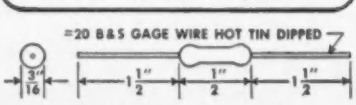
The entire resistor assembly is encased in Vitrohm enamel forming a hard, crazeless, heat-conducting hermetic seal. Leads are tin-dipped for fast soldering. No mounting hardware is required. Conservative 3-watt rating is based on 300°C rise, 40°C ambient.

Order these resistors by type number (3X) and resistance value (see table at right).

STOCK VALUES, TYPE 3X

Value* (Ohms)	Current (ma)	Value* (Ohms)	Current (ma)
1	1732	400	87
1.5	1413	450	82
2	1226	500	78
3	1000	600	71
4	866	700	66
5	776	750	63
7.5	632	800	61
10	548	900	58
12	500	1000	55
15	447	1100	52
20	387	1200	50
25	346	1250	49
30	316	1500	45
35	293	1750	42
40	274	2000	39
50	245	2250	36
75	200	2500	35
100	173	3000	32
125	155	3500	29
150	141	4000	27
200	123	4500	26
225	116	5000	25
250	110	6000	22
300	100	6500	21
350	93	....	..

Resistance tolerance ± 5 percent

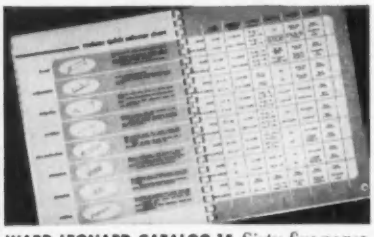


DIMENSIONS, Type 3X Resistor

You can still get 5- and 10-watt Ward Leonard miniatures

Ward Leonard 5- and 10-watt Axiohms have proved themselves in business machines, guided missiles, computers, communications equipment, and many other electronic and electrical devices. They have the same wirewound construction as the new miniature 3X resistor—differing only in size and wattage rating.

You'll find complete specification data on these larger miniature resistors in Ward Leonard's information-packed Catalog 15. (Complete data on the 3-watt unit will be found in Catalog 15, Supplement B.)



WARD LEONARD CATALOG 15. Sixty-five pages of data help you select the right resistor for any job.

And big ones, too!

Ward Leonard Vitrohm resistors are available in stock sizes up to 200 watts. Similar resistors up to 550 watts are made on special order. You'll find these *power* resistors in a wide variety of mounting styles and types, tapped, untapped and regular or non-inductive wound, described in our big Catalog 15. Write for your copy today. 6.9

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ABSTRACTS

Properties of Ti 75A Sheet

Abstracted from "Mechanical Properties of Ti 75A Sheet Titanium at Room and Elevated Temperatures" by D. C. Hayward, Royal Aircraft Establishment, Farnborough, Hants, England; Ministry of Supply, London, W. C. 2, Tech. Note Met. 210, referenced NACA N-42784.

Mechanical properties in tension and compression were determined on 16 S.W.G. (0.064 in.) sheet at room temperature, 200 C and 400 C in directions parallel with and transverse to rolling.

At each temperature the modulus of elasticity was found to be of the same order for both tension and compression in the direction of rolling, but transverse values exceeded longitudinal values. Ultimate tensile strengths were approximately the same in both directions, while yield strength values in the transverse direction generally exceeded those in the longitudinal direction. Elongation was greater at 200 C than at the other two temperatures tested.

Curves for stress-strain, tangent-moduli and secant-moduli are given.

Flight Safety Aspects Of Electrical Design

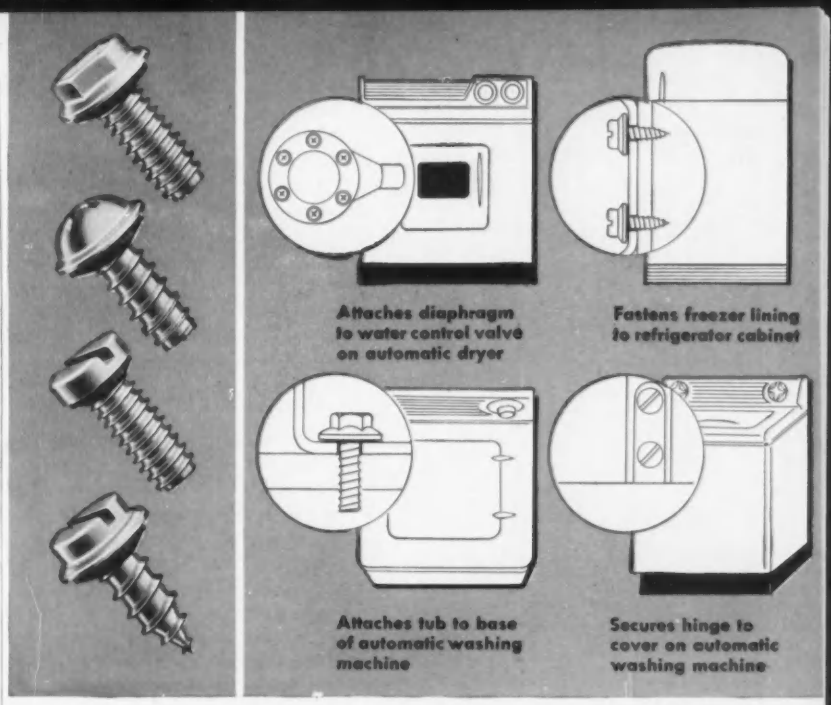
Abstracted from "Flight Safety Aspects of Electrical Design", by W. F. Funk, Convair, Fort Worth, Texas; *Electrical Engineering*, July 1956.

Design lessons learned from accident statistics indicate that present-day aircraft electric systems are basically well designed. However, detail mechanical design in electrically operated components must be improved to reduce accident potential.

For example, a fuel control valve was designed to be operated by an electric motor, but if necessary, the electric motor could be swung aside to expose a key to manually operate the valve in event of electrical failure.

During a climb it became necessary to switch to the last full tank to carry the airplane over the target and home to its base. When that tank was selected, nothing happened, and an immediate loss of fuel flow resulted. It was later found that a staked hinge

(Continued on page 364)


Attaches diaphragm to water control valve on automatic dryer
Fastens freezer lining to refrigerator cabinet
Attaches tub to base of automatic washing machine
Secures hinge to cover on automatic washing machine

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If you have a fastening problem, Townsend specialists will be glad to make recommendations as to the proper Tuff-Tite to meet your needs. If a standard item cannot be used, Townsend engineers will design a custom-made fastener to answer your purpose.

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3414 Milwaukee Avenue, Chicago 41, Ill.

pin had fallen from the valve and the electric motor had fallen from the valve assembly.

Present test specifications, calling for operation, for example, of a relay for perhaps 50,000 cycles under ideal laboratory conditions, are not realistic. A new item should be flight tested long before it is ready for production. Perhaps for certain applications, a million cycles of an electric apparatus should be called for in snow, rain, cold and sun during its operation, instead of in a 70 F room.

Physical characteristics and environmental limitations of man require that high-altitude, high-speed ultra-complex aircraft be tailored to the man or the crew.

An air crew is surrounded with a multitude of gadgets, switches, gages, instruments and other equipment. For example, when a fighter approaches its base under instrument conditions at 450 knots at 2000 ft, the pilot calls the tower, and is asked to switch to a different tower frequency for landing instructions. For the pilot to change to another radio frequency, he must first take his left hand off the throttle, and place it upon the stick—normally he would be flying the airplane with his right hand. He must then turn his head and stop monitoring flight instruments. With the right hand, and with the body and the head turned, he must reach for the channel and mode selector on the right wall of the airplane. This operation takes several seconds—but the airplane will strike the ground at 450 knots in 4 sec.

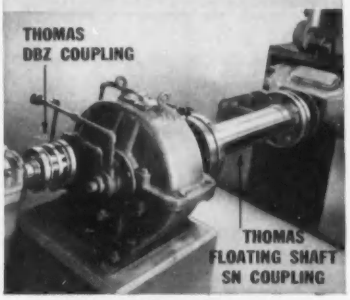
Progress has been made in the standardization of control knobs and levers. Miniature wheels for landing gear controls, miniature airfoil surfaces for flap controls, and many other items permit the pilot to differentiate his controls by feel are in use.

Lack of standardization of controls has also caused many accidents. For safety, electric switch panels and warning panels should be standardized from type to type and from model to model, so that the operators will not be jeopardized by nonstandard panels.

Engineering schools should include certain design teaching based on limitations of the human operator and upon accident analysis. Such teaching could possibly be included in the

(Continued on page 368)

Freedom From Coupling Maintenance



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First cost is *only* cost when you buy Thomas Flexible Couplings . . . because Thomas Flexible Couplings are correctly engineered . . . have no wearing parts . . . need no lubrication . . . eliminate future maintenance costs. Even more, Thomas all-metal couplings are open for inspection while running—ending inspection shut-downs!

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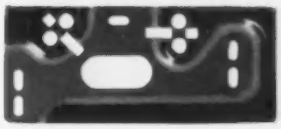

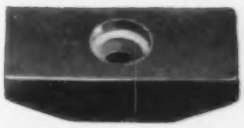

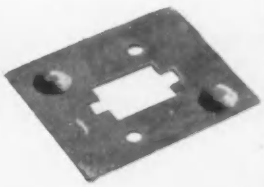

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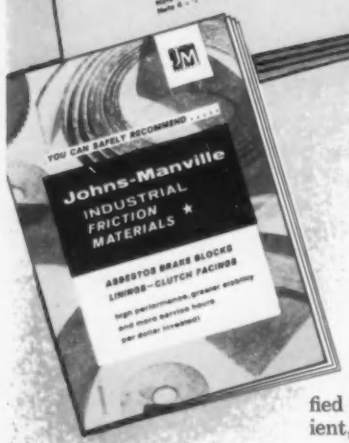

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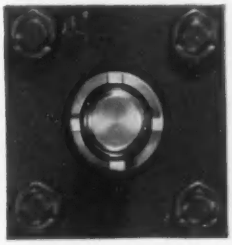

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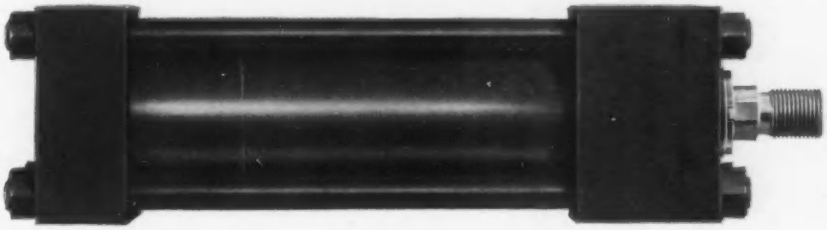

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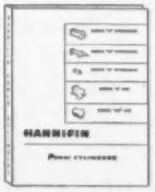

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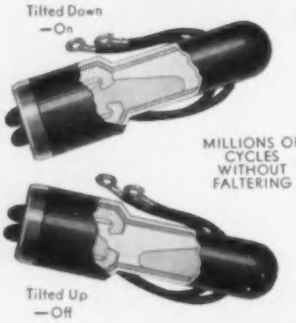

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High-Strength, Steel, Cellular-Core Sandwich Plates

Abstracted from "A Study of the Efficiency of High-Strength, Steel, Cellular-Core Sandwich Plates in Compression," by Aldie E. Johnson, Jr. and Joseph W. Semonian, Langley Aeronautical Lab., Langley Field, Va., National Advisory Committee for Aeronautics Technical Note 3751, Sept. 1956.

Structural efficiency curves are presented for high strength, stainless-steel, cellular-core sandwich plates of various proportions subjected to compressive end loads for temperatures of 80 and 600 F. Optimum proportions of sandwich plates for any value of the compressive loading intensity can be determined from the curves. The efficiency of steel sandwich plates of optimum proportions is compared with the efficiency of solid plates of high-strength steel and aluminum and titanium alloys at the two temperatures.

Sandwich plates of optimum design require the use of the minimum core thickness and density necessary to attain approximately the yield stress in the facing sheets at the design value of the structural index.

The weight of the core material relative to the weight of the complete sandwich plate decreases with increasing loading intensity. Except for low values of compressive loading intensity, the core thickness in steel sandwich plates of efficient design is small and consequently the weight of the core material is only a small percentage of the weight of the sandwich plate.

The compressive efficiency of a steel sandwich plate first increases with decreasing core density, but as the core density is reduced below about 2 per cent of that of the facing material, the

(Continued on page 372)

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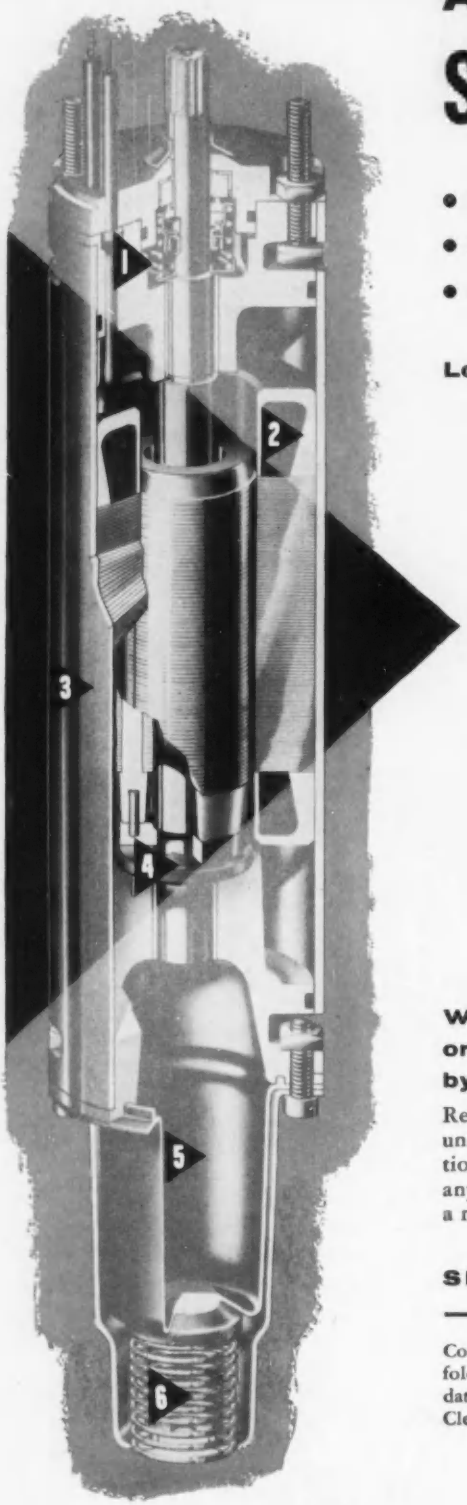

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3 *Corrosion-resistant Epoxy Paint Finish.*

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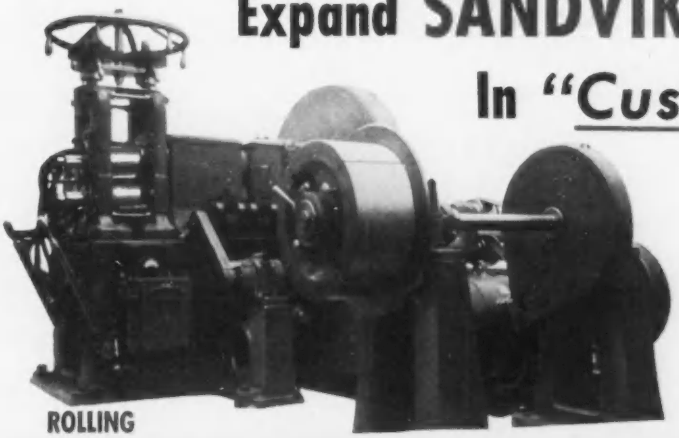

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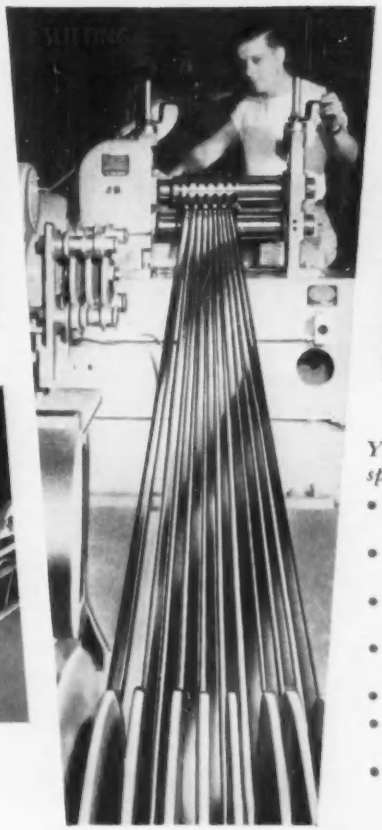

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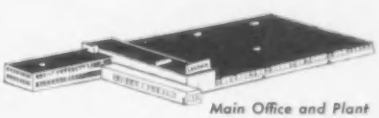

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shear stiffness of the core becomes an important factor and finally results in a decrease in efficiency at higher values of loading. At low loading intensities, there is little gain in efficiency by reducing the core density below approximately 2 per cent of that of the facing material. At high loading intensities, core densities approximately 5 per cent of that of the facing material are indicated to be near optimum.

At room temperature, steel sandwich plates can be built which are more efficient that solid plates of titanium alloy over the entire loading range considered and which are more efficient than solid plates of aluminum alloy over the lower part of the loading range. At 600 F, and over the entire loading range considered, steel sandwich plates are more efficient than solid plates of titanium alloy. For low values of loading intensity, the efficiency of steel sandwich plates at a temperature of 600 F is greater than the efficiency of solid plates of the aluminum or titanium alloys at 80 F.

For efficiently designed sandwich plates, the changes in weight associated with a change in temperature are closely related to the change in material yield stress with temperature.

High Temperature Bearing Operation

Abstracted from "High-Temperature Bearing Operation in the Absence of Liquid Lubricants," by S. S. Sorem & A. G. Cattaneo, Shell Development Co., Emeryville 8, Calif.; *Lubrication Engineering*, July-Aug. 1956.

Present-day liquid lubricants, used in high-speed anti-friction bearings, all have maximum temperature limits beyond which their performance characteristics begin to deteriorate rapidly by processes such as evaporation, thermal decomposition and oxidation. Engineering applications exist, however, which demand bearing operation at temperatures considerably in excess of the limits allowed by any present or immediately foreseeable liquid lubricant.

This report discusses mechanisms of failures in attempts to operate 206-size ball bearings at a speed of 10,000 rpm and temperatures up to 600 F without lubrication. By control of the environmental conditions

(Continued on page 374)

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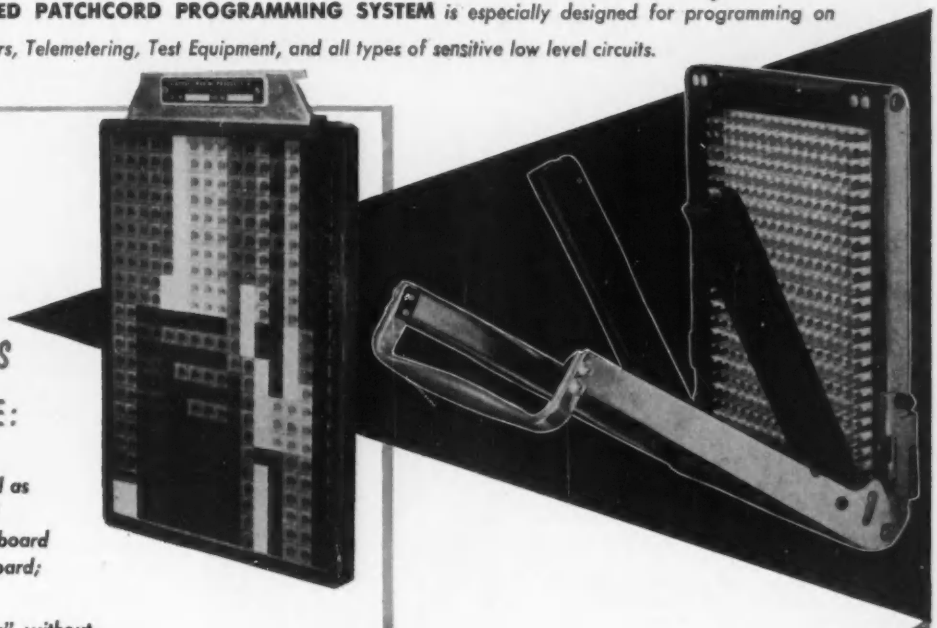
AMP's SHIELDED PATCHCORD PROGRAMMING SYSTEM *is especially designed for programming on Analog Computers, Telemetering, Test Equipment, and all types of sensitive low level circuits.*



NEW DESIGN FEATURES INCLUDE:

- *Fully insulated as well as shielded removable frontboard and fixed rearboard;*
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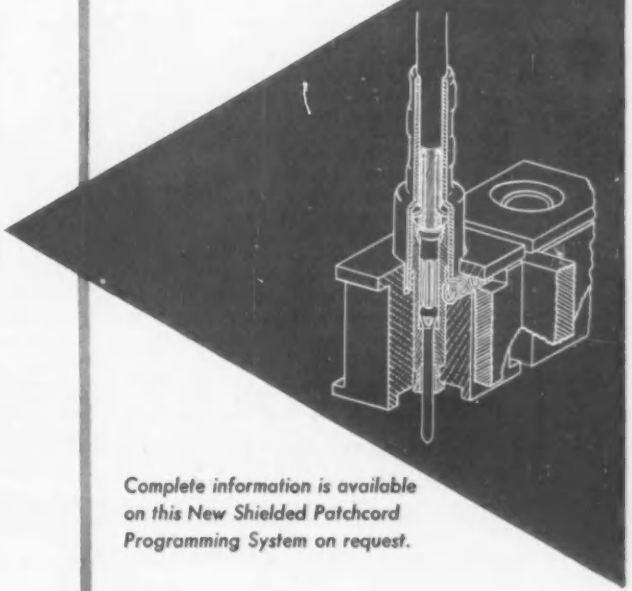
- *Custom Color-Coded circuit legend provided by a cellular type construction that permits individual hole identification;*
- *Elimination of signal leakage between circuits;*
- *Shielded Patchcords, with shield terminated by a contact ferrule, which connects to ground when Patchcord tip is inserted.*

The illustration shows how Berkeley Division of Beckman Instruments, Inc., is using AMP's new Patchcord System in its new EASE* 1200 Analog Computer.

*Trade Mark, Berkeley Division of Beckman Instruments, Inc.



Complete information is available on this New Shielded Patchcord Programming System on request.

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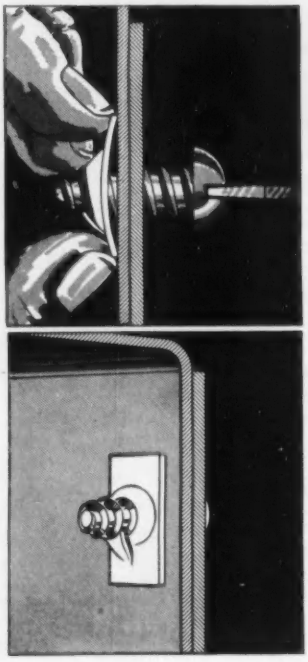

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of the bearing, certain of these failure mechanisms can be minimized, thus, extending the operating life of dry bearings from a matter of seconds to several hours.

The entire bearing housing in the test equipment is essentially a free-floating unit to permit self-alignment. Its weight is carried by the bearings and it is restrained from rotating by springs which also may be used to apply additional radial load. Stops prevent the housing from rotating more than a few degrees in case of jamming of the bearing.

For dry experiments the normal lubricant drain was closed and forced ventilation was supplied by continuous introduction of a metered quantity of the desired atmosphere through the lubricant supply jet. Excess blanketing gas escaped through the clearance space between the drive shaft and the housing. Test temperatures were measured by a thermocouple pressed against the outer bearing race through the unit's well. Elevated temperatures were maintained by eight cartridge heaters in the outer housing.

Ball and roller bearings were operated successfully in the tests at temperatures beyond the limits imposed by conventional lubricants used in the presence of air. The following conclusions have been verified:

1. When ball bearings are operated at high temperatures, metal oxidation and oxide-induced abrasion are the major causes of bearing wear.

2. A blanket of reducing atmosphere will eliminate bearing oxidation and minimize abrasion. A mixture of air and hydro-carbon vapor provides a suitable reducing atmosphere.

3. In the absence of bearing oxidation and oxidation-induced abrasion, cage scuffing becomes the limiting factor in the life of dry-running bearings.

4. Conventional extreme-pressure elements such as sulfur can increase the scuffing resistance of dry-running bearings. These may be applied by bearing pre-treatment, or as a volatile compound in the reducing-atmosphere blanket surrounding the operating bearing. It is preferable to use a combination of pretreatment and operation with a small concentration of the extreme-pressure element in the reducing atmosphere.

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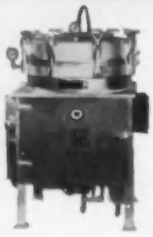

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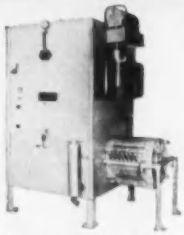

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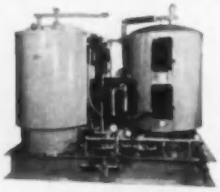

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NEW BOOKS

Principles of Computer Simulation

PB 121200, Special Devices Center, Office of Naval Research. 8½ x 11 *in.*, 158 pp. *Available from U. S. Dept. of Commerce, Washington 25, D. C.* $3.

This book is a basic reference covering operation and maintenance common to all analog-computer simulators. Part I of the two-part book covers general principles of analog computers. Part II describes individual components used in servo-mechanism and computer systems, and procedures in general maintenance. Most examples refer to the navy's operational flight trainers, although principles demonstrated are applicable to other simulators and analog computers.

A project of the Special Devices Center, Office of Naval Research, it is intended to bridge the gap between the better-understood synthetic trainer, such as the basic Link flight simulator, and increasingly complex modern trainers. Digital computers are covered briefly in the appendix with descriptions of arithmetic processes and a simplified outline of the binary system.

Symposium on Atmospheric Corrosion of Non-Ferrous Metals

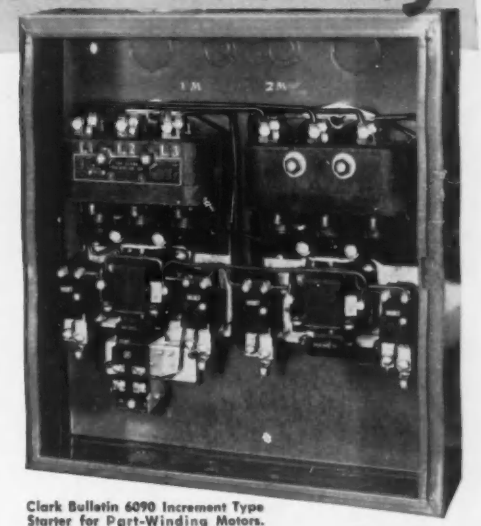
ASTM Technical Publication No. 175. Paperbound, 9 x 6 *in.*, 158 pp. *Published by American Society for Testing Materials,* 1916 *Race St., Philadelphia 3, Pa.* $2.75.

This symposium presents the results of a long-range test program begun 27 years ago by ASTM Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. In addition to the committee's report of the data, there are nine papers analyzing various phases of the program. Metals and alloys studied include aluminum, copper, lead, magnesium, nickel, tin

(Continued on page 378)

Two Outstanding CLARK CONTROLS for *"Cushioned" Motor Starting*

CLARK Increment Starters for Part-winding Motors and CLARK Reduced Voltage, Primary-resistor Type Starters are ideal for providing "cushioned" acceleration where requirements of the mechanical or electrical system indicate reduced torque-and-current starting. Both types offer the advantage of smoother acceleration and power application since the motor is not disconnected—eliminating mechanical and electrical shocks on the second step of acceleration. Both are available in sizes 1 through 7, with sizes 4 and smaller using the famous Clark Type "CY" starters which are setting new standards for dependability, low maintenance, and long life. Compact enclosures feature "safe-edge" design and generous wiring space.



Clark Bulletin 6090 Increment Type Starter for Part-Winding Motors. Integral Hinged Cover not shown.

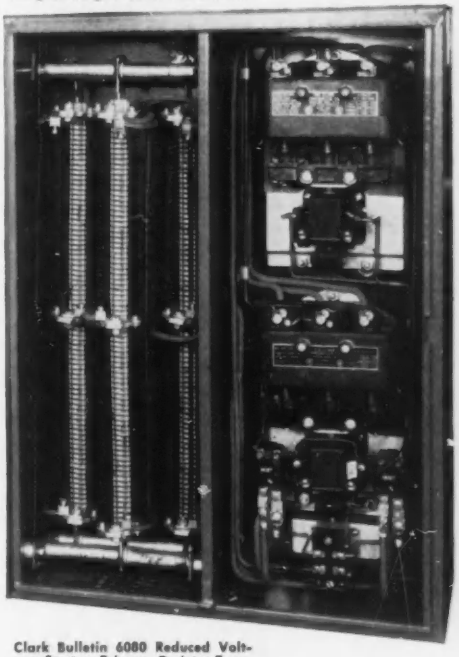
CLARK INCREMENT STARTERS FOR PART-WINDING MOTORS

Where part-winding motors can be used, this starter offers definite economical advantages. Because it has no resistors and uses smaller size contactors, a single compact enclosure reduces space requirements, and the initial cost is low compared to other types.

CLARK PRIMARY-RESISTOR TYPE REDUCED VOLTAGE STARTERS

This starter is applicable where higher starting torque is required. It offers greater flexibility of starting requirements and can be used on any squirrel-cage motor. It features the CLARK Edgewound non-breakable resistors—contactors and resistors are mounted in isolated compartments—where both are readily accessible.

For complete information on Clark Controls for "Cushioned" Starting, contact your nearest Clark sales office or write us direct.



Clark Bulletin 6080 Reduced Voltage Starter—Primary Resistor Type. Integral Hinged Cover not shown.

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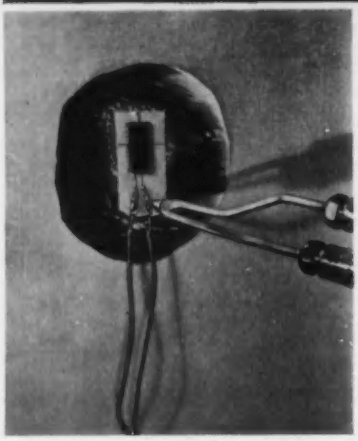
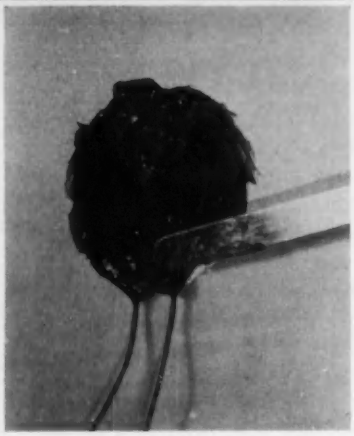


SURFACE OF STRUCTURE is lightly sanded. Strain gage is fastened in place and lead wires are soldered to gage. Gage is now ready for application of sealant.



PROTECTIVE COATING of "Thiokol" Liquid Polymer/epoxy compound is applied with spatula. Compound cures at room temperature in a few hours . . . forms tough, moisture-proof seal.

STRAIN GAGES WATERPROOFED WITH "THIOKOL" LIQUID POLYMER

Liquid Polymer/epoxy compounds safeguard gage accuracy

Delicate strain gages used to test the structural responses of jet and missile airframes are extremely vulnerable to moisture. Even an overnight dew on their sensitive wires necessitates complete drying and recalibration causing several hundred manhours delay. In hydrostatic tests, this water contamination problem has been a major obstacle to testing efficiency.

Moisture Problem Solved. For years engineers have searched for a suitable coating to seal strain gages against moisture. Today this problem has been solved by a new elastomeric alloy combining "Thiokol" Liquid Polymer with an epoxy resin. Produced commercially by the Epoxylite Corporation under the trade name "Epoxylite 222", this new compound can be applied swiftly and easily with a simple spatula. It cures rapidly permitting testing to proceed within a few hours. At no time during the process is heat application required.

Unaffected by water, the new coating compound adheres tightly to metal and most other materials, yet will not stiffen the surface to which it is bonded. It has excellent electrical properties and is easily removed with a hot, chisel-pointed soldering iron without damaging the tested structure.

Wherever moisture or other contaminants have been a problem, this new compound of "Thiokol" Liquid Polymer and epoxy resin makes possible safer, more reliable strain gage tests at less labor and less expense.

For information on "Epoxylite 222", write The Epoxylite Corporation, 10829 East Central Avenue, El Monte, California.

For more information on other "Thiokol" Liquid Polymer-modified compounds, write: THIOKOL CHEMICAL CORPORATION, 784 North Clinton Ave., Trenton 7, N. J. In Canada: Naugatuck Chemicals Division, Dominion Rubber Co., Elmira, Ontario.

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and zinc. Two papers deal with galvanic coupling corrosion. This volume supplements an earlier report issued in 1946 at the 10-year mark.

Standards on Light Metals & Alloys

Sponsored by Committee B-7 on Light Metals and Alloys. 9 x 6 in., 276 pp. Obtainable from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $3.50.

This third edition of ASTM standards on light metals and alloys, cast and wrought, includes not only those specifications and methods of test which come under the jurisdiction of Committee B-7, but also those for light metal alloy die castings prepared by Committee B-6 on Die Castings, and those for aluminum wire and cable for electrical purposes sponsored by Committee B-1 on Wires for Electrical Conductors. Several methods under the jurisdiction of Committee E-1 on Methods of Testing and Committee E-3 on Chemical Analysis of Metals as well as specifications for aluminum and aluminum alloy arc-welding electrodes and for brazing filler metal under the jurisdiction of the AWS-ASTM Joint Committee on Filler Metal have been included to round out the compilation.

The standards include ingots, castings, bars, rods, wire, forgings, pipe and tube, sheet and plate, wrought products for electrical purposes, filler metal, electroplating, and general methods of test. There is also included the ASTM codification system for light metals and alloys.

Practical Descriptive Geometry

HIRAM E. GRANT, *Professor, Washington University. 6 x 9 in., 403 pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y. $5.25.*

This book attempts to correlate and integrate theory and practice instead of considering each a separate entity. The transition from theory to practice is not necessarily obvious. Practical problems, because of the nature of their given information, frequently

(Continued on page 380)

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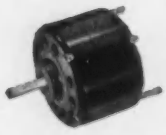
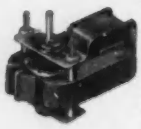
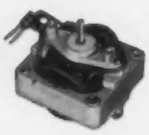


MODEL B
4-pole, 4-coil shaded pole AC Induction Type

MODEL A
2-pole, shaded pole AC Induction Type



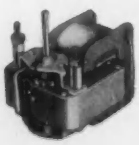
MODEL C
2-pole, shaded pole AC Induction Type



MODEL E
4-pole, shaded pole AC Induction Type

MODEL O
2-pole Capacitor Reversible Type AC only (for 6, 12, or 24 volts)

MODEL D
4-pole, 4-coil shaded pole AC Induction Type



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cannot be solved without considerable difficulty if an attempt is made to derive their solutions by using the typical theoretical approach. This is due to the difference between the factors that control the design of the practical and theoretical problems. Components of the machine control the practical problem's given information, while the author has complete control over the theoretical problem. For example, a theoretical problem would normally ask that a line be drawn tangent to a given parabola, while a practical problem would ask that a parabola be drawn tangent to a given line.

The alternate edition is the same as the regular edition, except that 925 problems have been added, made up of 405 theoretical problems and 520 practical problems. Most of the problem material was obtained by personal visits to approximately 300 United States and Canadian industrial firms.

Numerical Analysis Volume VI

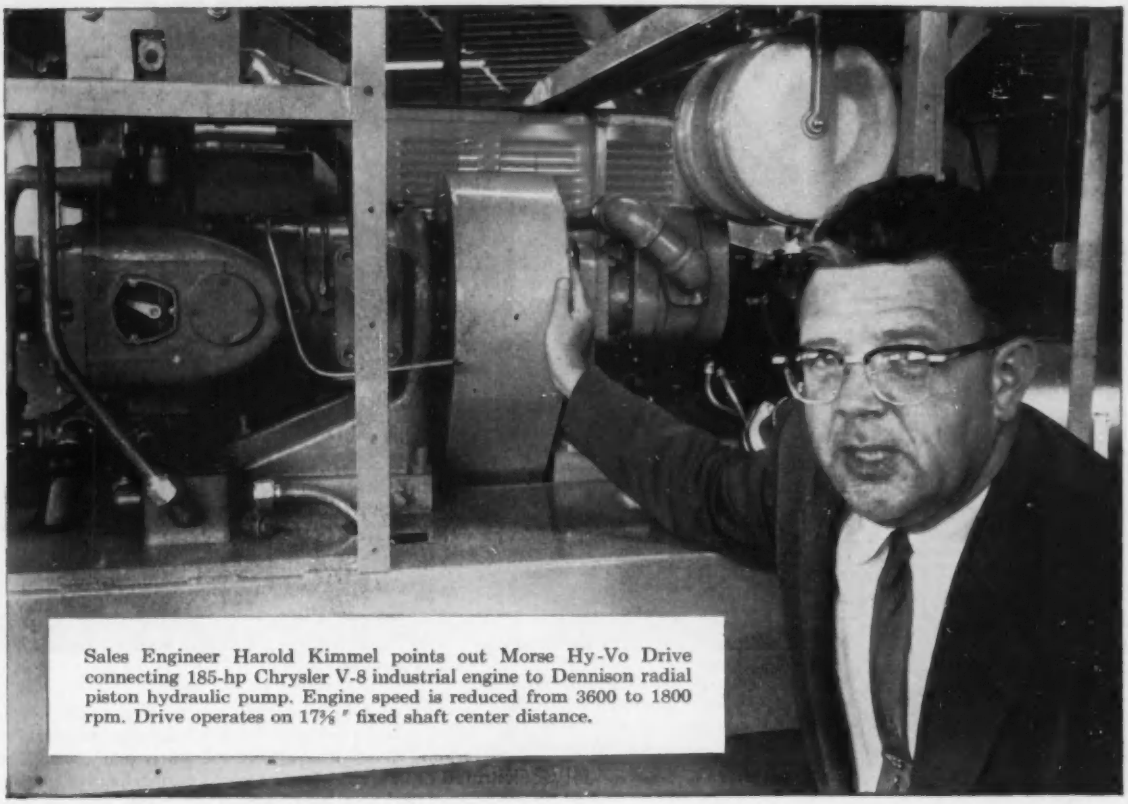
7 x 10 *in.*, 303 *pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y. $9.75.*

This volume contains all but two of the papers which were presented at the Sixth Symposium in Applied Mathematics of the American Mathematical Society. The Symposium was held at Santa Monica City College, Santa Monica, Calif., Aug. 26 to 28, 1953. The subject was Numerical Analysis and the National Bureau of Standards acted as co-sponsor.

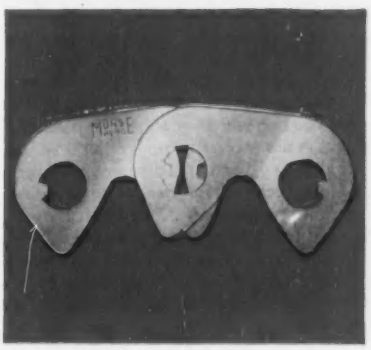
Ten or fifteen years ago, this branch of mathematics was attracting little interest among mathematicians. A glance at the table of contents of this volume will reveal very clearly how much the picture has changed: "Computational Problems in the Theory of Dynamic Programming," Richard Bellman; "Some Methods for Solutions of Boundary-value Problems of Linear Partial Differential Equations," Stefan Bergman, "Computational Aspects of Certain Combinatorial Problems," R. H. Bruck; "Numerical Results on the Shock Configuration in Mach Reflection," D. R. Clutterham and A. H. Taub; "Some Applications of Gradient Methods," Joseph W. Fischbach;

(Continued on page 383)

Morse HY-VO Chain offers designers high-hp capacity; space and cost savings



Sales Engineer Harold Kimmel points out Morse Hy-Vo Drive connecting 185-hp Chrysler V-8 industrial engine to Dennison radial piston hydraulic pump. Engine speed is reduced from 3600 to 1800 rpm. Drive operates on 17⅞" fixed shaft center distance.



Morse Hy-Vo's exclusive rocker-joint design and freedom from chordal action reduce wear and friction, eliminate stretch, and permit fixed shaft centers.

Narrow Hy-Vo Drive transmits power smoothly, efficiently at 6,250 fpm in new jet-engine starter.

In building the Pre-Flight Equipment Jet Hydrostarter, the basic design problem was to find a compact, efficient method of transmitting power from the primary motor to the pumps which actuate the hydraulic starting motor. In addition to providing a 50% speed reduction, the power transmission unit had to withstand reactive shock loads up to 100 hp, occurring each time the jet fuel is ignited.

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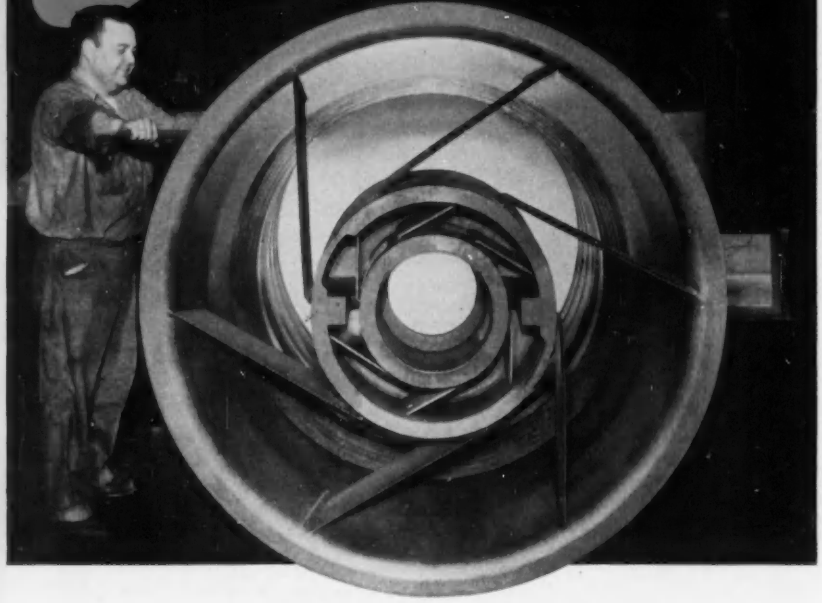

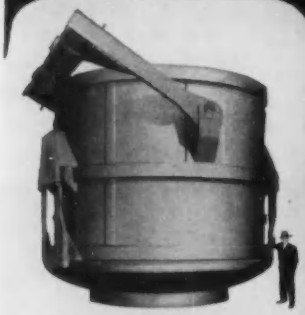

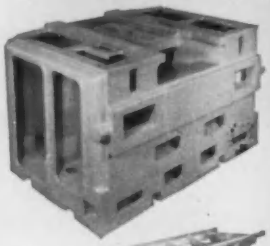

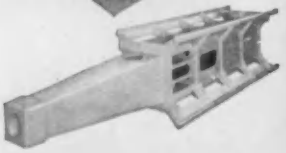

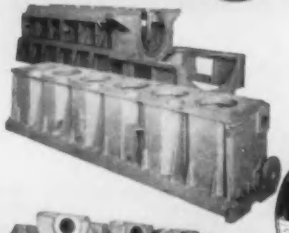

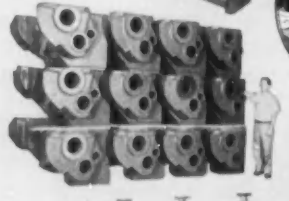

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"Some Qualitative Comments on Stability Considerations in Partial Difference Equations," S. P. Frankel; "Approximations in Numerical Analysis—A Report on a Study," Cecil Hastings, Jr., Jeanne Hayward, and James P. Wong, Jr.; "The Conjugate-gradient Method for Solving Linear Systems," Magnus R. Hestenes; "Number Theory on the SWAC," Emma Lehmer; "The Assignment Problem," T. S. Motzkin; "The Method of Steepest Descent," P. C. Rosenbloom; "Function Spaces and Approximation," Arthur Sard; "Some Computational Problems in Algebraic Number Theory," Olga Taussky; "Machine Attacks on Problems Whose Variables are Permutations," C. B. Tompkins; "Best-approximation Polynomials of Given Degree," J. L. Walsh; "Recent Results in Numerical Methods of Conformal Mapping," S. E. Warschawski; "On the Asymptotic Transformation of Certain Distributions into the Normal Distribution," Wolfgang Wasow; "Error Bounds for Eigenvalues of Symmetric Integral Equations," Helmut Wielandt; "On the Solution of Linear Systems by Iteration," David Young.

At present, extensive additional support for professional mathematical work in numerical analysis is being provided by the Office of Ordnance Research, the Atomic Energy Commission, the Air Research and Development Command, and the National Science Foundation. In addition, eight of the nineteen papers appearing in the present volume were written with direct or indirect support from the Office of Naval Research.

Standards On Metallic Electrical Conductors

6 x 9 in., heavy paper cover, 300 pp. Published by American Society For Testing Materials, 1916 Race St., Philadelphia 3, Pa. $3.50.

All of the ASTM standards pertaining to metallic electrical conductors, which were developed by Committee B-1 on Wires for Electrical Conductors, and related standards from other ASTM committees have been compiled. This Dec. 1955, edition includes in their latest form 52

(Continued on page 386)

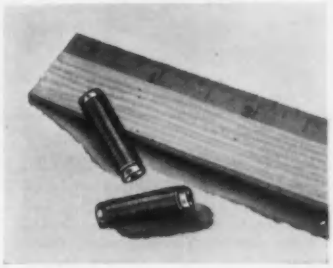
Production News from Bridgeport Thermostat

FROM THIS ALL-NEW PLANT—
MORE AND BETTER BELLOWS

On its new 15-acre site at Milford, Conn., Bridgeport Thermostat now has 180,000 square feet of automated production facilities to assure quick delivery of all the bellows or bellows assemblies you need . . . at the lowest possible cost. A temperature and humidity controlled room for charging bellows assemblies is only one of the many ways in which this ultra-modern plant promises you bellows assemblies of consistently high quality.

¼" DIAMETER BELLOWS

Progress at Bridgeport is typified by this tiny bellows for miniaturization. Available in seamless design with a wide range of characteristics in brass, phosphor bronze, beryllium copper and monel. Larger sizes available.



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THE POWER-RATED SYNCHRON LINE / A TIMING MOTOR FOR EVERY JOB

8 IN. OZ. TIMING MOTOR

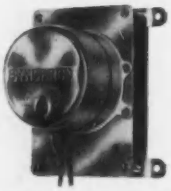
Widely used in timing machines, time switches, heating and air conditioning controls, action signs, recording thermometers, and other timing devices. Guaranteed to pull 8 in. oz. direct load continuously at 1 r.p.m.

20 IN. OZ. TIMING MOTOR

Ideal for timing motor applications requiring continuous high torque power. Instant starting, dependable accuracy, and flexible installation. Call for Synchron's guaranteed 20 in. oz. at 1 r.p.m. power when your job calls for long, continuous torque.

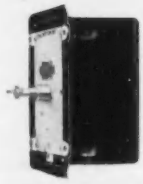
1 R.P.H. TIMING MOTOR

Guaranteed to pull 20 in. oz. at 1 r.p.h. (1/60 r.p.m.) Synchron's especially developed motor for slow motion timing applications. Eliminates need for extra reduction gears between 1 r.p.m. and 1 r.p.h. in intermittent time trains. Gives gear train with lifetime lubrication; enclosed and trouble-free.



SYNCHRON TIMING MACHINES

An almost unlimited number of shaft speeds. Synchron Motor fixed to a rigid frame. Easy to mount and connect in any position. Trouble-free, accurate. Drives everything from liquid recorders to program clocks and washing machine timers. Highlights complete versatility of famed Synchron Line.



SYNCHRON CLOCK MOVEMENTS

For standard and office clocks, sign clocks, novelty clocks, and clocks of all kinds up to 26" in diameter under glass. Split-second accuracy and long wearing construction, never needs oiling. Furnished with front, rear or bottom set, with or without dustproof case.

MAGNA-TORC D.C. MOTOR

Designed originally for use in aircraft instruments and radio control mechanisms. During World War Two the Hansen Magna-Torc proved its rugged dependability in all altitudes and in all climatic conditions. Now this motor is being adapted to many commercial applications.

"Workhorse of the industry"

*Synchron synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140°F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

Synchron timing motors in all speeds available for prompt delivery

SYNCHRON®

SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNATORC D.C. MOTORS

HANSEN MFG. CO., INC.

OUR 50TH YEAR

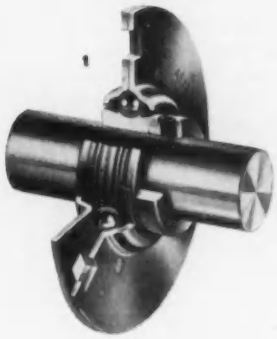
Princeton 5, Indiana

HANSEN REPRESENTATIVES: The Fromm Co., 5254 W. Madison St., Chicago, Ill. R. H. Winslow Assoc., 123 E. 37th St., New York, N. Y. Electric Motor Engineering, Inc., 8255 Beverly Blvd., Los Angeles 48, Cal. and 3907 Lyon Ave., Oakland, Cal. H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton, New York.

Aetna

SEALED, PRE-LUBRICATED BALL BEARING package UNITS

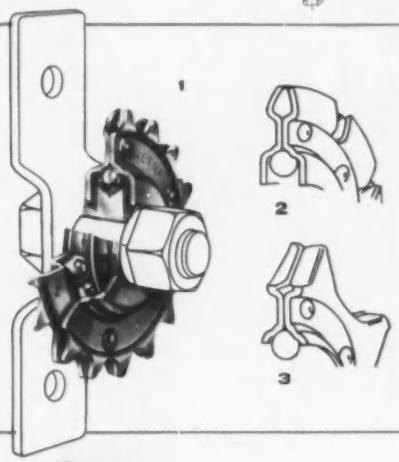
Easy To Apply . . . Require No Maintenance . . . Inexpensive



ADAPTER UNIT

Designed for light-duty moderate-speed applications, this multi-purpose economy-priced unit mounts easily, quickly, wherever shafts can be supported—on sheet metal or any semi-rigid structural members. Sealed, pre-lubricated bearing is self-aligning; takes radial, thrust or combined loads. Available in 4 shaft-locking types, (1) with eccentric locking collar,* (2) with ball lock,‡ (3) with two set screws,‡ (4) drilled for roll-pins.‡

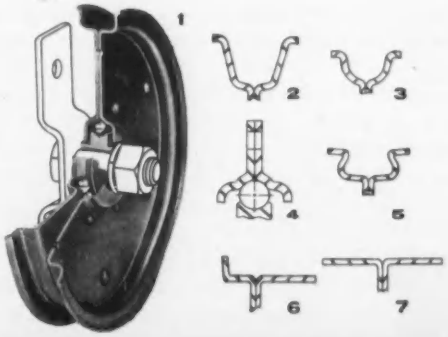
*Standard ‡On special order



SPROCKET IDLER UNIT

A sprocket idler and pre-lubricated, sealed, ball bearing —*all-in-one*. Bearing has triple-capacity lubricant chamber, full complement of balls for greater load capacity, 4-point ball contact for greater rigidity, case-hardened inner and outer races. Bore sized for ⅝" or ½"* mounting bolts—available with sprockets (as illustrated) to fit (1) standard pitch, (2) extended pitch roller chain or (3) detachable link chain.

*On special order



BELT IDLER UNIT

Designed and built-to-be-installed-and-forgotten this permanently lubricated, sealed-for-life idler unit requires no re-lubrication, no maintenance of any kind. It combines bearing, seals, and pulley in a single, compact, easy-to-install *package* assembly. Bore sized for ⅝" or ½"* mounting bolts. Sheaves (available in 7 types illustrated) and bearing outer race are of heavy-gauge, case-hardened steel.

*On special order

GET THE FACTS . . .

See how these low-cost units can be adapted to either your current or projected equipment designs with minimum, or no, engineering alterations. Write us or call in our local expert, your nearby Aetna distributor.

Aetna

AETNA BALL AND ROLLER BEARING COMPANY
Division of Parkersburg-Aetna Corporation
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SPECIAL
ATTACHMENTS
provide great
versatility
for
CONVEYOR
CHAINS

Acme Precision conveyor chains are easily adapted to special requirements by the use of stock or specially designed attachments. Possibilities for modification of Acme standard chains are practically endless. In all adaptations, Acme engineers are skilled in retaining as many standard parts as possible to reduce costs.

Most attachments are in reality special plates which take the place of standard chain plate and are stamped from dies in production quantities. Attachments in smaller lots can be hand machined, cast, bent or welded to your specifications.

Whether you use a simple extended pin design or more elaborate attachments used for timing and motioning special conveyor lines, Acme engineers are ready to design practical applications for you.

All Acme conveyor attachments available in stainless steel for the packaging and food industries. Write our engineering department.

FREE CHAIN CATALOG

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Call ACME for Service

Acme Chain Corporation
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standards—43 specifications, seven test methods, one recommended practice and one classification of coppers.

Standards cover: (1) copper, copper alloy and copper-covered steel: wire; stranded conductors; rods, bars and shapes; pipes and tubes; (2) aluminum: wire; stranded conductors; rods and bars; (3) galvanized steel core wire; and galvanized iron and steel guy, messenger, span, overhead ground, and line wire. Of the material included in this compilation, 20 of the specifications have been revised and one of the standards is new since the previous edition.

Metallic Materials At Temperatures Above 1600 F

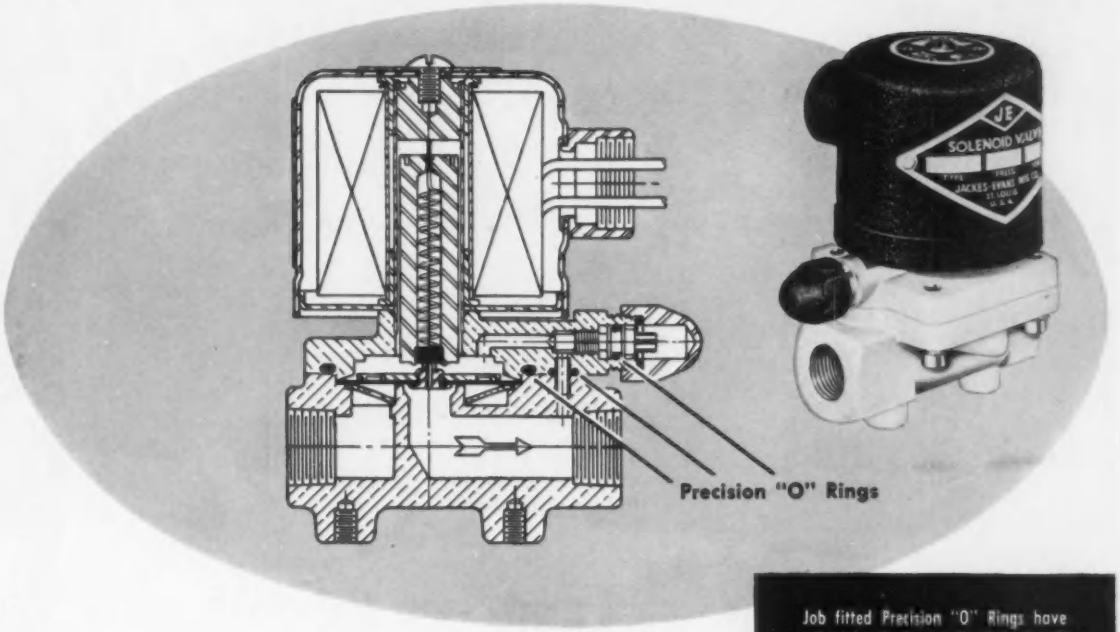
6 x 9 in., heavy paper cover, 200 pp. Published by American Society For Testing Materials, 1916 Race St., Philadelphia 3, Pa. $3.

This material was developed at a symposium, sponsored by the general research panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. This was an attempt to provide a basis of evaluation for a number of metallic materials, including cermets, which have been undergoing study in laboratories both here and abroad, to determine their suitability for higher temperature service. Paper discusses as many as possible of the properties, physical, chemical and mechanical, as well as methods of combatting surface deterioration that are affected by temperature.

Titles included in the symposium are: Some Sheet and Bucket Materials for Jet Engine Application at 1600 F and Higher; Influence of Boron on Cast Cobalt-base S-816 Alloy; Effect of Heat Treatment and Structure Upon Creep Properties of Nimonic Alloys Between 750 and 950 C; Stress-Rupture Properties of Inconel 700 and Correlation on the Basis of Several Time-Temperature Parameters; Chromium-Nickel Alloys for High-Temperature Application; Effect of Rare Earth Additions on High-Temperature Properties of a Cobalt-Base Alloy; Creep Rupture and Notch Sensitivity Properties of S-816 Alloy up to 1650 F Under Various Combinations of Fatigue and Static Stress; Titanium-Carbide Base Cer-

(Continued on page 390)

SPECIAL PRECISION "O" RING meets low temperature flexibility requirements



Resiliency maintained at 1 P.S.I.

Precision "O" Ring compound 233-70 was developed especially for refrigerant service. It is used in the solenoid valves manufactured by Jackes-Evans Company of St. Louis, Mo. This compound assures the right chemical resistance and low temperature flexibility required for uninterrupted, maintenance free operation of refrigeration equipment using Freons.

Precision has developed thousands of special "O" ring compounds to provide the exact chemical and physical properties required for each specific job. Precision "O" Rings are quality controlled – compression molded – rigidly inspected – the finest made! They are made to all military and commercial specifications in hundreds of sizes.

What is your sealing problem? There is an expert – the Precision engineer – ready to help you in product design and "O" ring specifications. You can rely on him – and on Precision, the world's largest exclusive producer of "O" Rings. Put Precision in your plans!

Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.

Hot water circulation for heating in thousands of Levittown homes is controlled by Jackes-Evans Solenoid Valves—made extra dependable with Precision "O" Rings.

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

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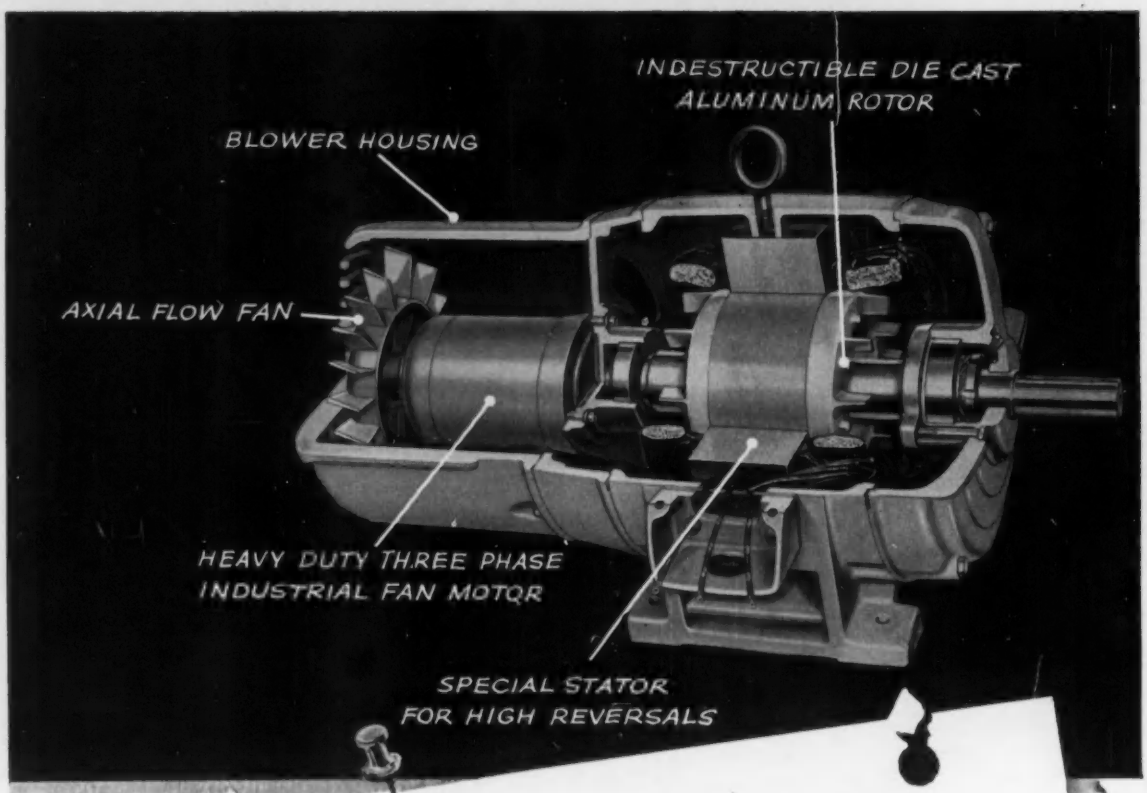
Canadian Plant at: Ste. Thérèse de Blainville, Québec



212 idle reversals per minute*

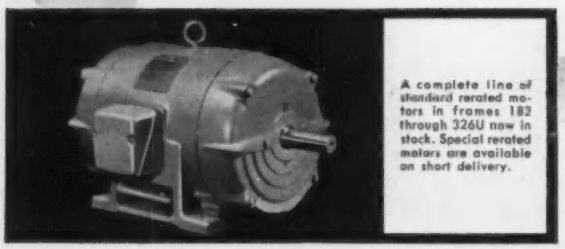
Special blower assembly continuously cools Louis Allis rapid-reversing motors, to permit high rate of reversals

Here's a motor built especially to withstand the tough demands of rapid reversal applications. It is kept cool by its own integrally mounted blower that forces cooling air through the motor and over the windings and end rings.

Other factors that lead to long dependable motor life are: Large stator slots and special slot shapes that allow maximum copper in the windings. Specially annealed and coated lamination steel that reduces losses and increases the number of reversals possible. New Phenolic impregnating varnish that protects the insulation with outstanding thermal and chemical resistance for Class A insulation. Also built with Class B and H insulation.

These reversing motors meet standard NEMA mounting dimensions except for the increased length caused by the addition of the blower. And you can get constant torque or constant horsepower ratings in single and multiple windings for two or more speeds. Sizes range from 1/2 to 15 hp. See your Louis Allis field engineer for complete information about this remarkable new motor development.

Send for bulletin 1800 describing these new motors.



A complete line of standard rerated motors in frames 182 through 326U now in stock. Special rerated motors are available on short delivery.

*3 HP, 1200 RPM with Class H Insulation

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

WAUKESHA casts all 3

STAINLESS STEEL
Group I — Martensitic
Group II — Ferritic
Group III — Austentic

NON-FERROUS
Monel Pure Nickel, Inconel
Brass and Bronze, Aluminum
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WAUKESHA METAL
Copper Base, High Nickel Content Corrosion-Resisting Alloy. Developed and Produced Only by Waukesha Foundry Company.

to meet your design needs... in these modern facilities...

● "Top" product designs and process equipment in every field require "top" castings.

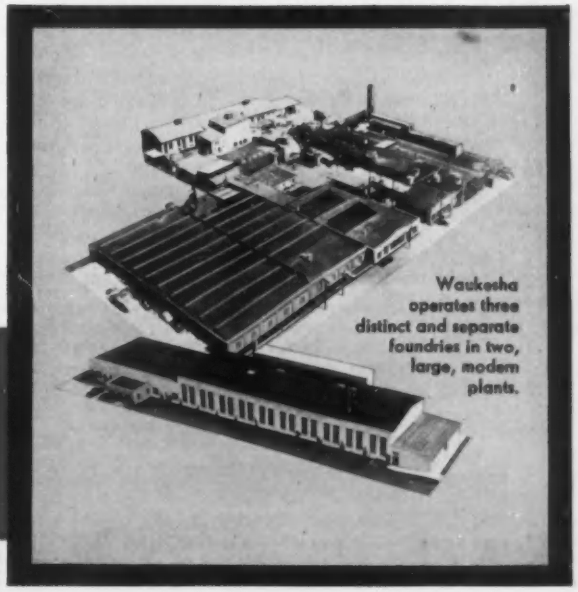
Especially is this so where there is a critical corrosion-resistant casting design problem combined with one of hardness, or strength, elongation, wear resistance, bearing qualities, impact, scale resistance, seizing or galling, or intergranular corrosion among others.

Waukesha has the right metal and the casting ability to produce castings precisely to specifications . . . castings that stand up to the severe demands of today's designs and process equipment demands.

Metallurgical laboratory control guarantees you castings that are uniform, close-grained, free of porosity, metallurgically accurate in composition, and dimensionally correct—real assets to your products.

We suggest that you write for a casting quotation or engineering counsel.

Waukesha Foundry Company,
5603 Lincoln Avenue, Waukesha, Wisconsin.



Waukesha operates three distinct and separate foundries in two, large, modern plants.

Waukesha Foundry Company
WAUKESHA, WISCONSIN

WAUKESHA—SPECIALISTS IN CORROSION-RESISTANT CASTINGS FOR ALL INDUSTRIES

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WOVEN WIRE CONVEYOR BELTS take the bottlenecks out of WASHING, DRYING, PACKAGING

OPEN MESH of rustproof, all-metal belt provides free circulation of process solutions and drying air; assures waste-free packaging.

Whether you're processing slab, sheet or pelletized materials . . . or packaging bottles, drums or bags . . . Cambridge Woven Wire Conveyor Belts combine movement with processing. Continuous belt-to-belt flow through washing and drying cycles, roasting kilns, and weighing and sealing operations cuts cost and provides controlled uniform production.

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. . . metalworking, food, chemical, ceramic or glass . . . whether the machines are for your own operation or resale, you'll find "open mesh" only one property of Cambridge belts that makes combined movement and processing practical and economical. Open mesh construction also provides rapid drainage of process solutions. Belts are corrosion resistant and impervious to heat damage, even at 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt. Cambridge Woven Wire Belts are made in any size, mesh or weave; from any metal or alloy. Special surface attachments are available to hold products during inclined movement.

Call in your Cambridge FIELD ENGINEER to discuss how you can cut costs by continuous operation. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

mets for High-Temperature Service; Titanium-Carbide Products Produced by Infiltration Technique; High-Temperature Properties of Molybdenum-Rich Alloy Compositions Made by Powder Metallurgy; Tension and Torsion Tests on Nimonic Alloys at High Temperatures; Thermal Fatigue Testing of Sheet Metal; Development of Zirconium-Rich Protective Coatings and Brazing Materials for Heat-Resisting Alloys.

Fundamental Mathematics

THOMAS L. WADE, *Professor of Mathematics*, HOWARD E. TAYLOR, *Associate Professor of Mathematics, Florida State University*. 6½ x 9½ *in.*, 380 *pp. Published by the McGraw-Hill Book Co., Inc.*, 330 W. 42 *St., New York* 36, *N. Y.* $4.75.

This book is intended as a survey and text for study for students not prepared for the usual first year college mathematics. It provides a foundation for such courses. The authors have tried to strike a balance between teaching mathematics for understanding and teaching for manipulation.

The basic ideas of elementary algebra, for example, are covered in a manner intended to give the student a more unified grasp. It is expected that the volume will also be of use to persons in industry needing to review their mathematics through self-study. Here are some of the chapter headings: Mathematics as a Language; Mathematical Systems; Fundamental Operations with Integers; Fundamental Operations with Fractions; Simple Equations; Ratio, Proportion, Percentage; Measurements; Exponents; Quadratic Equations; Business Mathematics; Some Topics in Statistics; Logarithms; Additional Topics in Algebra.

Principles of Chemical Engineering Thermodynamics

E. D. WILSON AND H. C. RIES. 6 x 9 *in.*, 376 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 W. 42 *St., New York* 36, *N. Y.* $7.50.

"The authors firmly believe that the only way to obtain the student's active interest in thermodynamics is to show him where and how the sub-

(Continued on page 394)

Millions of strokes

(at 300 strokes per minute)

—NO MEASURABLE WEAR!

that's how Decco's New Oil-Immersed Solenoid can perform for you

Decco's OIL-IMMERSED solenoid is so superior in performance and dependability, it is in a class by itself. Here are some of its outstanding features:

1. Individually sealed in oil. No oil contamination.
2. Unbelievably little wear.
3. Efficiency increased. Power loss cut to amazing new low.
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5. Built with best mechanical features of Decco Standard Solenoids.
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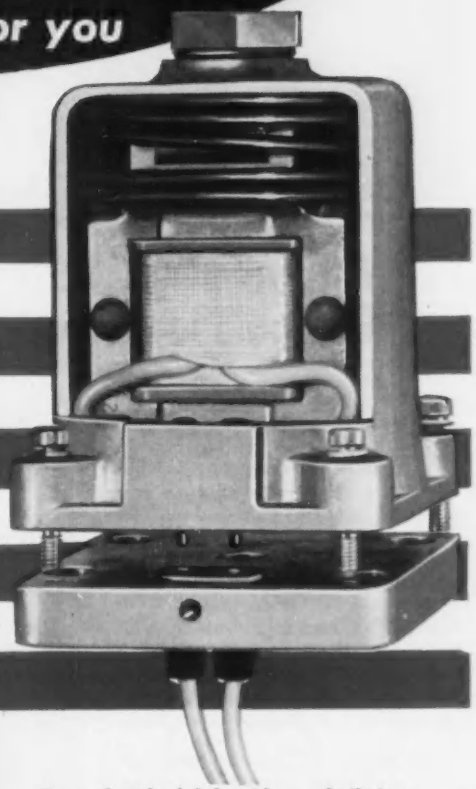

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Decco Standard Solenoids are built in a complete range of sizes and types. Write for complete information.

DETROIT COIL COMPANY

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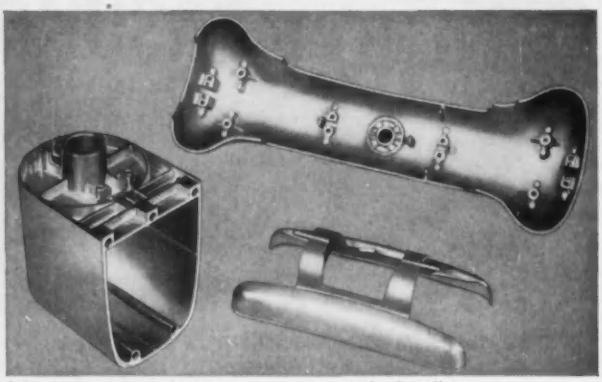
DIE CASTING REPORT

Uniformity - - Less Machining - - - Corrosion Resistance - - Close Tolerances - - are a Few Reasons Why

This wringer-type Maytag washer has 24 die-cast parts.



Wringer parts include: gear case, cap and clutch pulley.

Formerly sandcast, this washer cover is now an aluminum die-casting.

Maytag uses 15 to 20 million die cast parts per year!

Having produced over 9 million washing machines, no one knows better than Maytag Co. the importance of maintaining quality while meeting high production schedules. Die castings have helped solve the problem — at economical unit costs — by providing unlimited qualities of identical component parts. At the same time, aluminum and zinc die-castings have met the critical demands of functional applications. Examples of Maytag requirements. die castings must be (1) oil and water tight for gear cases and housings (2) true to dimension for line assembly with mating parts and (3) free and clear of external surface flaws.

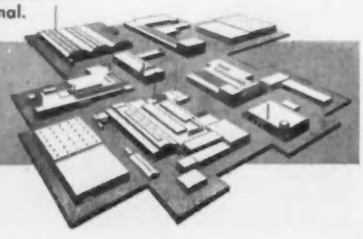
While Maytag is a large user, those with lower requirements may enjoy similar economies and advantages. Let our creative design engineers look at your functional or decorative part needs, at no obligation of course.

For a copy of: "Die-Castings Unlimited." Address: Precision Castings Company, Inc., 199 Walnut Street, Fayetteville, N. Y.

Small zinc die-cast components, mostly functional.

Switched to die castings from sand castings

Many of the die-cast parts in the Maytag automatic and wringer-type washer were formerly sandcast. Less machining, better surface quality, reduced finishing time are reasons for the changeover. Precision is one of the major die-casting suppliers to Maytag... and has been since 1938.



PRECISION CASTINGS CO.

A DIVISION OF **HARSCO Corporation**

FAYETTEVILLE, N. Y. — SYRACUSE, N. Y. — CORTLAND, N. Y. — NEW YORK, N. Y.
CHICAGO, ILL. — CLEVELAND, OHIO — KALAMAZOO, MICH.

Now despite skyrocketing costs... International gives you

... UP TO 24% MORE FOR YOUR POWER DOLLAR

IN 6 NEW CARBURETED POWER UNITS!

Your choice of fuel

International's adaptable design permits you to take advantage of your local fuel situation and select either gasoline, LPG or natural gas equipment in all six power units.

Now...you can get up to 24% more for your power dollar! International gives you this horsepower bonus, plus additional *new* savings on fuel, and *extra* life in six new, heavy-duty, 6-cylinder carbureted power units, from 68 to 133 net hp.

Horsepower increases and lower prices result from money-saving mass-production techniques unrivalled in the industry. Three of the power units, the U-264-6, U-308, and U-370 are *special* adaptations of heavy-duty International truck engines—proved for top *worry-free mileage*, and *record ton-mile economy!*

So, compare low first cost per working hp of these new International units with any other make. And compare such International *bonus* features as positive, unfailing lubrication through rifle-drilled oil passages... famous International valve-in-head operating efficiency ...power-smoothing, counter-balanced forged crankshafts ...and positive, "filter-clean" crankcase ventilation. Prove you'll get more dependable hp per dollar...more profits to depend on from every dollar you invest. Compare soon—see your International power unit distributor.

Brief Specifications (Gasoline)*

Model	Net hp and rpm	Max. torque lbs.-ft.	Displacement	Bore & Stroke
U-220	68 @ 2400	177	220.5	3⅞x3 11/16
U-264-6	78 @ 2400	192	264.3	3 11/16x4⅛
U-308	87.5 @ 2400	229.5	308.2	3 13/16x4½
U-372	104 @ 2200	288	372	4⅜x4⅛
U-450	126 @ 2200	323	450.9	4⅜x5
U-501	133 @ 2200	384	500	4½x5¼

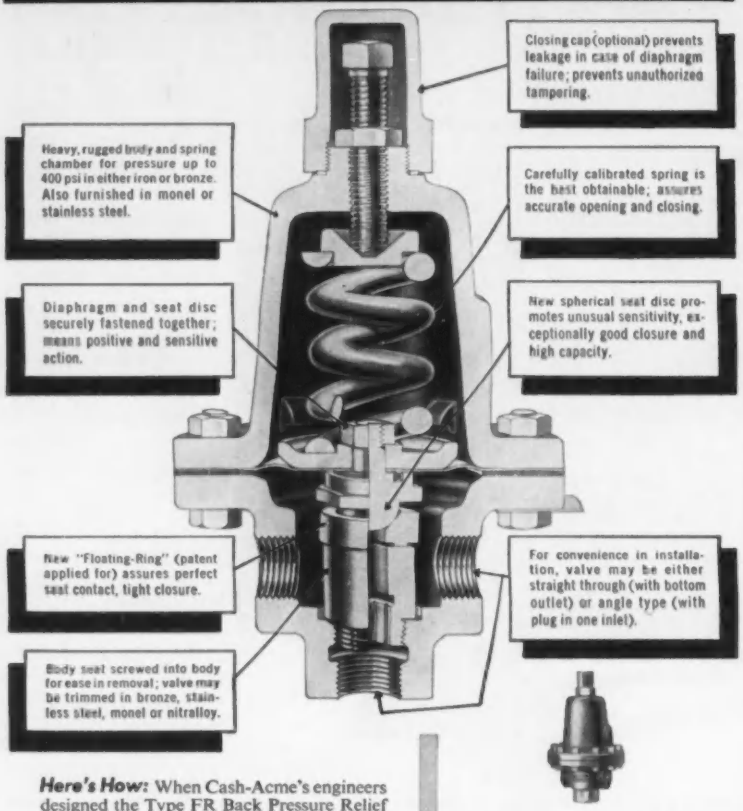
*Complete specifications and ratings on LPG and natural gas available on request.

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors... Self-Propelled Scrapers and Bottom-Dumps... Crawler and Rubber-Tired Loaders... Off-Highway Trucks... Diesel and Carbureted Engines... Motor Trucks.

INTERNATIONAL® CONSTRUCTION EQUIPMENT

International Harvester Company
180 North Michigan Avenue, Chicago 1, Illinois

how Cash-Acme provides the Correct Answer to high back pressure valve maintenance costs


Closing cap (optional) prevents leakage in case of diaphragm failure; prevents unauthorized tampering.
Heavy, rugged body and spring chamber for pressure up to 400 psi in either iron or bronze. Also furnished in monel or stainless steel.
Carefully calibrated spring is the best obtainable; assures accurate opening and closing.
Diaphragm and seat disc securely fastened together; means positive and sensitive action.
New spherical seat disc promotes unusual sensitivity, exceptionally good closure and high capacity.
New "Floating-Ring" (patent applied for) assures perfect seat contact, tight closure.
For convenience in installation, valve may be either straight through (with bottom outlet) or angle type (with plug in one inlet).
Body seat screwed into body for ease in removal; valve may be trimmed in bronze, stainless steel, monel or nitralloy.

Here's How: When Cash-Acme's engineers designed the Type FR Back Pressure Relief Valves, they put *your* rising maintenance costs foremost in mind . . knowing that "down time" is extremely important. This superior valve series, therefore, is built to *exacting* specifications, featuring the nearest thing to *friction-free* operation as is possible to attain, which means less wearing of parts, longer life.

Do as other cost-conscious engineers and purchasing men are doing and switch to CASH-ACME.

A fact-jammed bulletin, with honest and accurate capacity charts, is available free of charge. Write today.

TYPE "FR"—Rugged Industrial Type Back Pressure Relief Valve, automatically maintains correct pressure on inlet, relieving to a lower pressure or to atmosphere. For 0 to 400 psi; ½" to 2" pipe sizes. Suitable for:

- AIR • WATER (Hot or Cold)
- GASOLINE
- OIL (Light or Heavy)
- FUEL TAR • AMMONIA
- FREON • BRINE • CO_2
- FISH OIL • NITROGEN
- HYDROGEN • ALCOHOL

Modified for:

- VACUUM RELIEF
- CONSTANT DIFFERENTIAL REGULATOR

FOR THE *Correct Answer*

CASH AUTOMATIC VALVES ACME

A. W. CASH VALVE MANUFACTURING CORP.

6662 East Wabash Avenue

Decatur, Illinois

ject can be of use to him. Therefore, thermodynamics has been presented here as a tool and a method of approach to the solution of industrial problems."

The book has been prepared especially for undergraduate engineering students. The principles of thermodynamics are presented on the basis of the perfect-gas law: complications resulting from deviations from this law on the part of real gases are not introduced until the last third of the book.

This particular arrangement may be questioned, especially in a book which stresses the practical application of thermodynamics, but Chapter 12, "Real Gases Versus Ideal Gases", is so written that it can be taken up jointly with or before the others.

Thermodynamic data for the solution of problems in Appendix D are given in Appendix A. The thermodynamic data for steam are not given. For these, standard steam tables should be used. Appendix B deals with the free energy of formation of water-soluble solids and offers a semi-empirical method for calculating them from solubility data. The calculation of frictional losses on the basis of empirical equations and curves obtained experimentally for a number of fluids are shown in Appendix C.

Problems are numbered with the Chapter and subhead number which applies.

Dynamic Factors in Industrial Productivity

SEYMOUR MELMAN. 5½ x 8½ in., approx. 240 pp. *Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.* $4.75.

Mechanization of production and rise of administrative overhead are parallel processes taking place in industry today, according to the author. The two processes have opposite, but not equal, effects on the productivity of industry's man-hours.

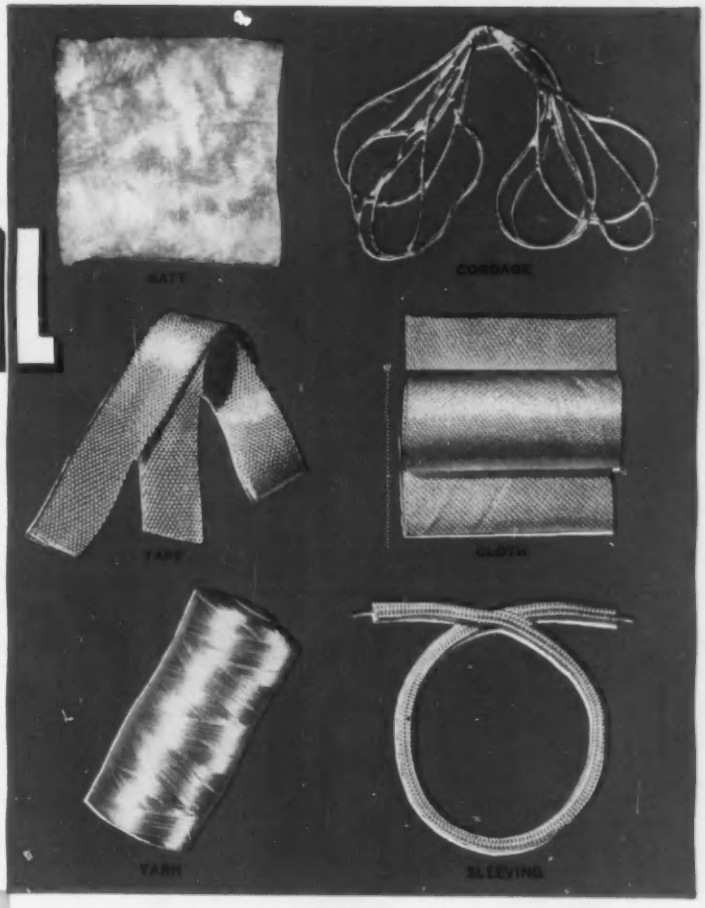
The book is the result of investigations carried on in the United States and Britain. It covers developments in manpower utilization in a number of industries, it traces the role of administrative personnel and its assumption of wider and wider func-

(Continued on page 398)

where can you use REFRASIL

2000°-3000° F.
High Temperature Insulation

...it may be the special insulation you've been looking for!



REFRASIL PROPERTIES:

- Chemical resistance of pure silica
- Resists temperatures up to 3000°F. under certain conditions
- Low Thermal conductivity
- Fiber diameter .00020—.00040 in.
- Specific heat .19
- Thickness .14—.15 in.
- Surface density .05 lb./sq. ft.

REFRASIL USES:

- 2000°F. continuous high temp. insulation
- Filtration of corrosive materials
- Removable, insulating blankets
- REFRASIL and plastic laminates
- Thermocouple wire insulation
- Electric muffle furnaces
- Laboratory heating mantles

REFRASIL INSULATING BLANKETS:

"WRAP-AROUND"

"PRE-FORMED"

WHAT IS REFRASIL? REFRASIL is a highly efficient fibrous silica insulation material, extremely light in weight and bulk and made in a variety of physical forms.

REFRASIL has proven its high temperature insulation ability in millions of hours of jet aircraft operation. It is fast becoming an important industrial insulation for critical and extreme temperature applications from −300°F. cold to +3000°F. heat. Despite relatively high initial cost, REFRASIL is economical when restricted to special high temperature uses where ordinary insulation materials fail.

If you need an efficient, lightweight 2000°-3000° insulating material in bulk fiber or any of the physical forms shown, REFRASIL may be your best answer. For your *special* high temperature insulation problems, our research and development engineers are only a phone call away. Call or write for complete engineering information and free samples of REFRASIL, for your own testing.

• FREE NEW CHART!

First of a Series, this new High Temperature Insulation Chart contains helpful information on insulation for temperature ranges from −300° to +3000°F. Write for your free copy today!

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HITCO HELPS INDUSTRY BEAT THE HEAT

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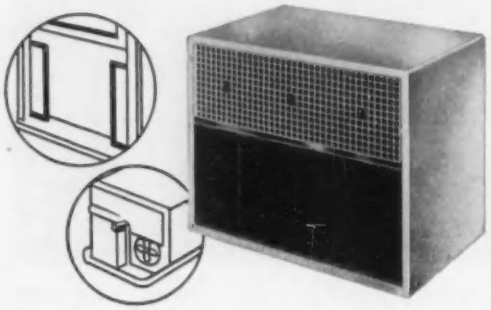
PICKER X-RAY equipment showing Rubatex as soft resilient cushioning pad to support patient in comfort during x-ray examinations. Highly radiolucent, Rubatex makes no perceptible difference in the radiograph. Will not soak up barium salt solutions or other fluids—wipes clean with damp cloth and needs no cover.



The Rubatex Closed Cellular Rubber gaskets applied in 1956 G.E. THIN LINE ROOM AIR CONDITIONERS are designed to effectively seal out moisture, dirt and drafts. Shown in cutaway drawing are two Rubatex seal gaskets on the window closure panel and one behind the control plate of the unit.

Rubatex pad oscillates on base of PORTABLE ELECTRIC TOOL's industrial sanding unit. Reduces vibration to minimum. Resists deterioration from solvents used in industrial sanding jobs.

doing unusual jobs unusually well for 20 years

Rubatex's 20-year record meets the demand of industry . . . cost-wise and performance-wise . . . in doing thousands of unusual gasketing, sealing, cushioning, packaging, sound deadening and vibration isolation jobs better and cheaper than ordinary soft rubber materials.

From hearing-aid "cushioning" to packing for scientific instruments to radio and electronic dust-proof seals to special aircraft, automotive and electrical appliance sealing applications . . . here's tested proof of a versatile material worth your investigation. Offers advantages no other soft rubber materials can. Why not give Rubatex a test? Write us today.

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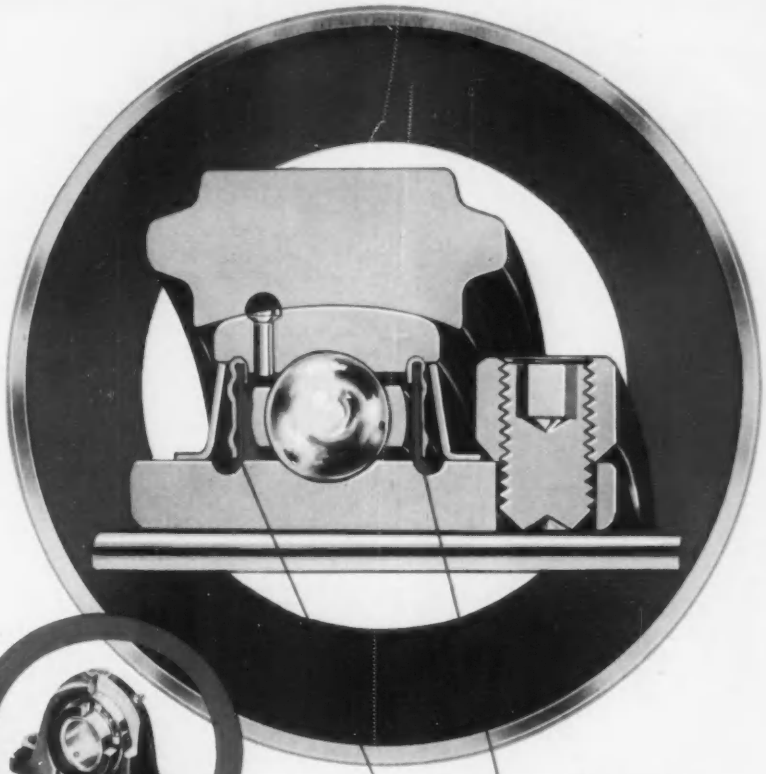
RUBATEX DIVISION, Bedford, Virginia



Type SY Unit Pillow Blocks
For set-screw mounting.
Shaft diameters: ¾" thru 4".

New Type SYH-X Unit Pillow Blocks
For eccentric lock mounting.
Shaft diameters: ¾" thru 2-7/16"

Type FY Unit Flanged Mountings
For set-screw mounting. Shaft diameters: ¾" thru 2-15/16".

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For eccentric lock mounting. Shaft diameters: ¾" thru 2-7/16".

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- Lubricant can escape only when new lubricant is added
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The combination of the Red Seal and a rotating flinger assures you the best sealing arrangement available.

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tions, and the interaction that takes place between administrative and engineering functions, though it does not dwell on the concomitant rise of the engineer as industrial administrator.

Having thus established the trend, the author investigates its implications, dealing with the effects of these forces on engineering and on the business process, both here and in Britain. What he finds is an ever-widening gap between American and British productivity.

Arc-Welded Machinery Construction in Mild Steel

A. G. THOMPSON. 7¼ x 9½ *in.*, 36 *pp. Published by British Welding Research Assn., 29 Park Crescent, London W1, England. About* $1.

This concise, well written and clearly illustrated booklet fills a long felt need for clear and authoritative information in the field.

After comparing welded steel with cast steel and riveted construction, it enumerates the principles of welded structure design, it analyzes static and fatigue loading and allowable stresses, and it offers a wealth of design and fabrication details.

Cost reduction factors are listed, though some of them are more in the field of shop rules than that of design consideration.

Development of Improved Titanium-Base Alloys

PB 111988, H. A. ROBINSON, W. M. PARRIS *and* P. D. FROST, *Battelle Memorial Institute for WADC. Paperbound,* 8½ x 11 *in.*, 104 *pp. Available from Office of Technical Services, Commerce Dept., Washington* 25, *D. C.* $2.75.

The heat-treated properties of 24 alpha-beta titanium alloys are evaluated in a report of research for the air force just released to industry through the Office of Technical Services, U. S. Dept. of Commerce.

Manganese, molybdenum, and vanadium were the principal alloying additions. The strength-ductility relationships of these alloys increased with increasing alloy content up to about 7 per cent alloy addition, and

(Continued on page 403)

UNDERWRITERS LABORATORIES test and approve

new DINGS Explosion-Proof Magnetic Disc Brakes for Hazardous Locations

The new Dings "700" Series Explosion-proof Magnetic Disc Brakes are now Underwriters Laboratories Approved . . . the "707" Series for Class I, Group D hazardous locations . . . and the "709" Series for Class I, Group C as well as Class II, Groups E, F and G.

The "707" Series Brakes are built to withstand an internal explosion within U.L. limiting requirements. The "709" Series meets explosion requirements, and also includes a thermal release to automatically release the brake if the housing temperature approaches the limits set by U.L. as dangerous for possible ignition of various dusts, etc.

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- Standard motor shaft extensions are used; no special brake shaft required.

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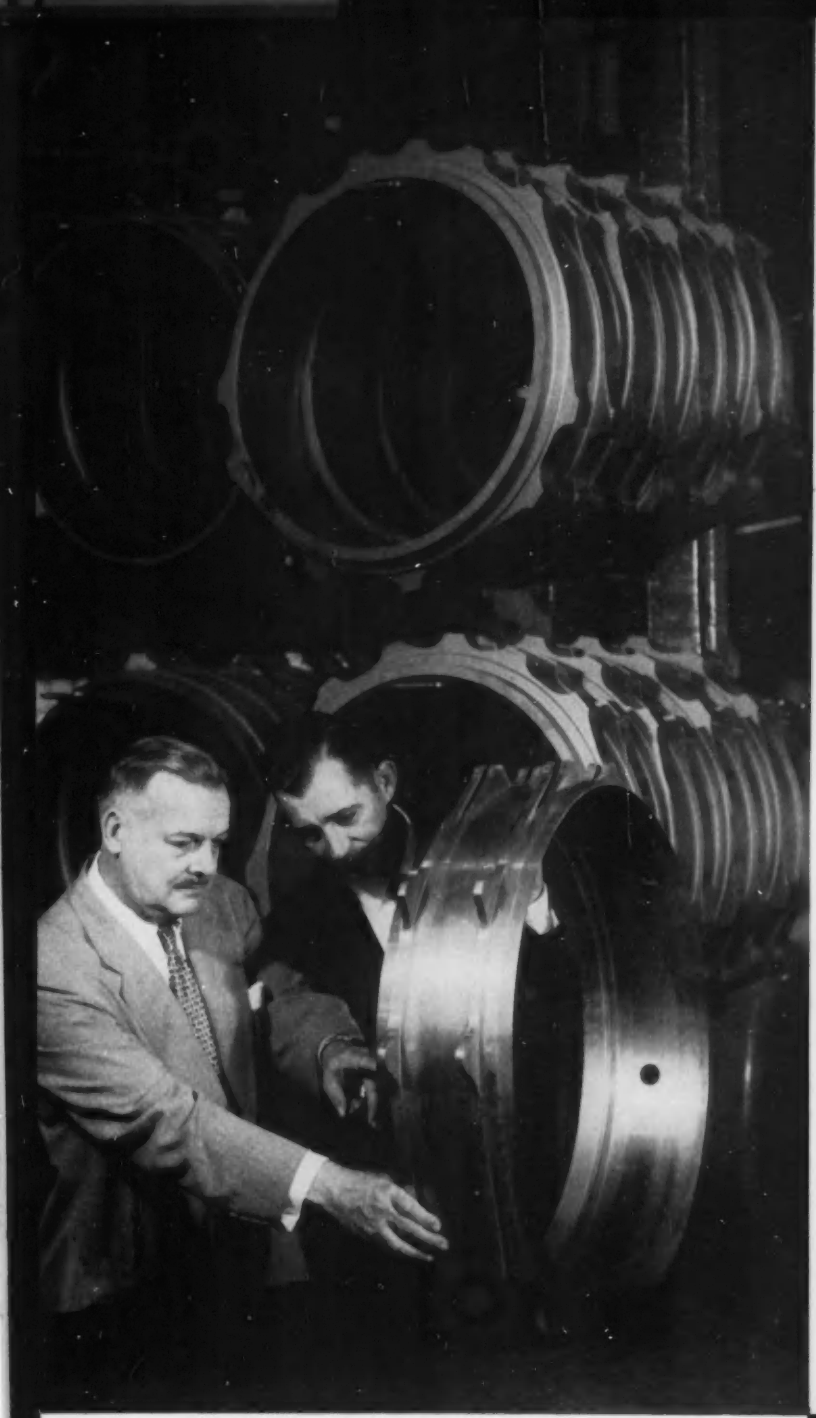

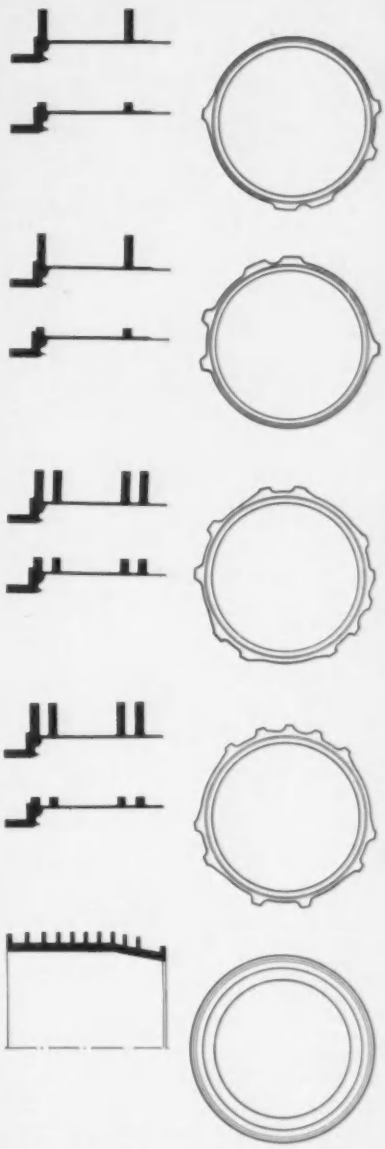

Typical ring sections and profiles showing lug configurations in a smaller scale.

STAINLESS STATOR RINGS

One of Cameron's most interesting contributions to military and commercial air-power today is the production of forged, stainless steel, stator rings. Our unique processes make possible precision forgings with odd lug configurations, large diameters and a vastly superior grain structure. Shapes and sizes heretofore costly to produce as a forging are now sound economy at Cameron.

The study of specialized alloys to meet the extreme demands of today and to anticipate those of tomorrow parallels forging production and is a part of our progress.

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Technical-ities

By John S. Davey

What's the right torque for bolts?

This is one of the toughest questions we're asked. Too many variable conditions. But the following may help.

The bolt takes two stresses during wrenching: (1) Torsion, (2) Tension. Tension is what you want. Torsion is the necessary evil due to friction. Probably 90% of applied torque goes to overcome friction.

With the friction factor changed by lubrication, plating, etc., the torque needed to produce a given tension is hard to predict. However, a useful empirical formula exists for *normal* friction conditions.

Inch-lbs. Torque = 0.2 x bolt diameter x bolt tension

Many tests show that the 0.2 torque coefficient is approximately constant for the usual friction conditions, for all diameters, and for both coarse and fine thread. Average deviation is about 7%. But when are conditions *"normal"?* The only *sure* way to check torque is to set up a pilot assembly and try it out.

In pilot testing for rigid joints, tighten a few bolts with torque wrench to failure, and then set torque at 75% of that load; or even at yield strength, since torsion component vanishes leaving bolt under tension only, which is well below ultimate strength.

We've worked up curves giving suggested torques for various size bolts. Send for a copy.

How to make a stronger joint

From research on structural steel joined with high strength bolts come facts applicable to *products:*

These bolts can be torqued to high tension for a large clamping force on joined members. Resultant friction overcomes shearing forces and prevents slippage. The higher compressive forces also protect bolt holes from fatigue cracks. Moreover, the tighter the bolt, the less chance for loosening, and the less risk of bolt fatigue due to dynamic loading.

High strength bolts are stronger in shear, too. In recent tests, rivets and "soft" bolts broke under extreme shear load; but high strength bolts didn't—the joined steel failed first.

APPLYING THE ADVANTAGES

Since high strength bolts have 2 to 3 times more tightening strength than common bolts, smaller diameter bolts can be used. As discussed above, these make a stronger joint; also weigh and cost less.

Along with good joint design, it's important that fasteners used can meet requirements. For example: A manufacturer designed vibrating machinery for high tensile bolts, but it was assembled with low carbon bolts. Joints failed. RB&W high carbon bolts with hardened washers solved the problem.

Moral: *Specify* even your standard fasteners.

RB&W selects the proper grade of steel to give "Empire" high strength fasteners the precise balance between *tensile strength* and *ductility.*

Feel free to call on RB&W for help in selection and use of standard, low cost fasteners.

Three radial dashes on bolt head denote a high strength bolt. The "E" identifies Empire bolts, an RB&W trademark. These markings assure highest quality standard fasteners with full strength, and uniformity of size and physicals.

Russell, Burdsall & Ward Bolt and Nut Company . . . plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Silicon bronze fasteners combine desirable features

Silicon bronze offers the highest conductivity of fasteners able to withstand high stresses. It resists corrosion, stays free from season cracking, too. It makes ideal fasteners for electrical use where tensile strength is important; or for corrosive environments.

One of the first to develop such fasteners, RB&W cold works them for tensile strength and for clean, well formed threads that don't seize. Oval bolts, hex bolts and nuts and U bolts available. Specials can be developed.

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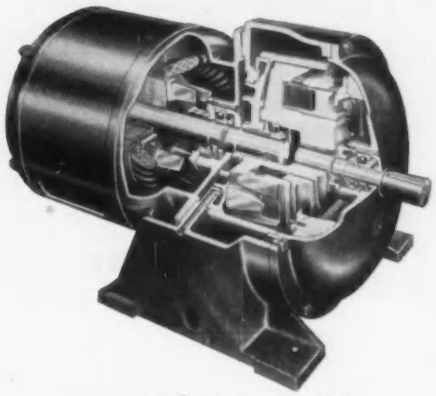


Dynaspede® Stationary Field Coupling, with Integral Motor

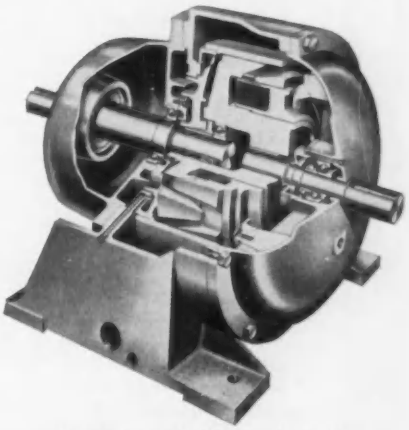
Dynamatic stationary field couplings are the simplest drives so far devised to provide infinitely adjustable speed from an alternating current source. The absence of rotating coils, brushes, slip rings, and commutators in this design holds wear and maintenance to an absolute minimum. Dynamatic electronic or magnetic amplifier controls, in combination with these drives, provide wide latitude in operating functions.

Check these Outstanding Advantages:

Accurate speed control • Wide speed range • Low power losses • Simple construction • Rapid response • Remote control • Quiet, efficient operation • Low maintenance costs

Ajusto-Spede® Drives: Air cooled, stationary field eddy-current couplings mounted integrally with D-flange open drip proof squirrel cage motors are available in capacities from 1 to 75 HP. Units of the same design and capacities are also available without motors.

Dynaspede® Drives: Liquid cooled, stationary field couplings mounted integrally with D-flange squirrel cage motors are available in capacities from 3 to 75 HP. Motor types available are drip proof, splash proof, totally enclosed fan cooled, and explosion proof. The coupling is totally enclosed. Separately mounted couplings are also available in capacities from 3 to 2500 HP and larger.



Stationary Field Coupling for use with Separately Mounted Motor

Send for Detailed Information on these New Stationary Field Couplings and Drives

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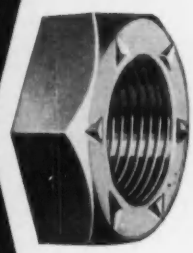

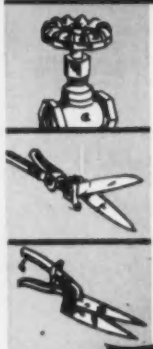

or wherever you need a positive lock on short bolts where the strength of a full nut is not needed.

GRIPCO JAM NUTS come in the New Unified Finished and Heavy Series (Hexagon), in standard full and jam dimensions, in steel, brass and aluminum.

Gripco Products Include:
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the Ti-3Mn-complex alloy had room-temperature properties slightly better than those of any of the other alloys tested. However, a Ti-5-Mn-2V alloy exhibited excellent elevated-temperature stability at 650 F.

A binary Ti-8V alloy proved interesting in that it could be quenched from the beta-phase region and aged to give very good properties. Most alloys are embrittled as a result of being heated into the beta-phase region.

It was found that pickling to remove the air-contaminated surface of alloy sheet added large amounts of hydrogen. A process was developed for descaling and pickling titanium-alloy sheet without appreciable hydrogen pickup. Using this process, the Ti-3Mn-complex alloy sheet was heat treated to 180,000-psi tensile strength with over 10 per cent elongation in 1 in.

Development of Heat Resistant Paints

PB 111957, M. Kornbluth, Corps of Engineers, U. S. Army. Paperbound, 8½ x 11 in., 153 pp. Available from Office of Technical Services, Commerce Dept., Washington 25, D. C. $4.

This report covers: (a) the development of a lusterless, olive-drab, corrosion-resistant paint (for steel surfaces), capable of withstanding temperatures up to 1400 F without film deterioration or loss of protective properties, and (b) the preparation of a procurement specification for this type of paint. The paint is intended to reduce the accelerated oxidation and rapid destruction of steel components which, under normal conditions of use, are heated to high temperatures in oxidizing atmospheres.

Laboratory test methods were developed, and commercial heat-resistant paints were evaluated. None of these paints was adequate, and an extensive literature and patent survey showed that little work had been done in this field; therefore, experimental investigations were initiated. Experimental studies indicated that these paints were adequate, and a paint consisting of a blend of ceramic frits, pigments, and refractories at a pigment volume concentration of 35

(Continued on page 405)

BARBER COLMAN Small Motors

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Twenty-four hours a day, over a 22,000 mile network, Weather-Fax facsimile recording machines automatically reproduce weather maps, charts, drawings, other pictorial data. To do this, each Weather-Fax drive system is synchronized with Weather Central in Washington, D. C. Power to drive the recording stylus mechanism in the recording unit is supplied by a Barber-Colman KYAB unidirectional motor. Reasons for choosing this motor as reported by Weather-Fax makers are: "It provides more power for its size than other types; has low inertia and high starting torque, the latter an important advantage in this particular application. Reliability was another factor in its selection."

the complete line of Barber-Colman motors includes unidirectional, synchronous, and reversible motors — up to 1/20 hp. With and without reduction gearing — open or enclosed types. Expert engineering service available to help you get the exact motor for your application. Write today for free copy of Catalog F-4271-6.

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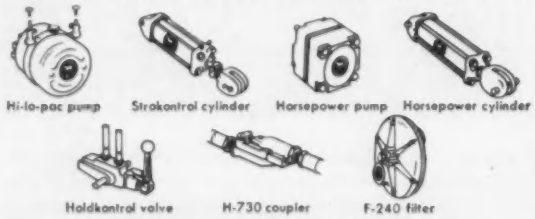
- ✓ Built-in HOLDKONTROL. This frees the operator from holding the valve in operating position. The valve can be manually returned to neutral, or it will return by itself when pressure exceeds the relief valve setting.
- ✓ Built-in relief valve. Large capacity. Can be set to operate at standard pressure settings . . . 500, 750, 1000, 1500 and 2000 P.S.I.
- ✓ Can be easily converted to control either single or double acting systems.
- ✓ Can be converted to complete manual operation—simple field change.
- ✓ Has 3 point reversible mounting—can be mounted in any position.
- ✓ Will withstand surge pressures up to 5000 P.S.I. It can be safely connected to virtually any hydraulic system.
- ✓ Will sensitively handle volumes from 2 G.P.M. to above 12 G.P.M.
- ✓ Swivel control handle can be rotated through 360 degrees to the most convenient operating position.
- ✓ Special 3-way control without Holdkontrol available for loaders, lift-trucks, etc. Spool change allows operator to inch load up or down.

SPECIFICATIONS

CAPACITY 2 gpm to 12 + gpm • **SAFETY** Relief valve can be set to protect for any range of operation up to 2000 psi • **MATERIAL** Precision-cast body of high tensile strength aluminum bearing alloy. Hardened ground and lapped spool • **PORTS** ¾" N.P.T.—Inlet and outlet.—½" N.P.T.—Cylinder ports • **MOUNTING** Any two of the three pads can be used. Pads reversible for alternate top or bottom mounting • **CONTROL** Spring-loaded . . . Control handle returns to neutral. Handle swivels 360° and may be operated in the most convenient position • **SYSTEMS** Open or closed center. Single or Double Acting. Open free flow or restricted flow • **HOLDKONTROL** Valve will hold when placed in an operating position until it is either manually returned to neutral or until the relief valve operates which releases the lock. This lock can be turned on or off by regulating a screw on operating port face.



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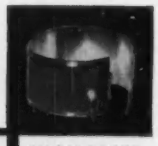

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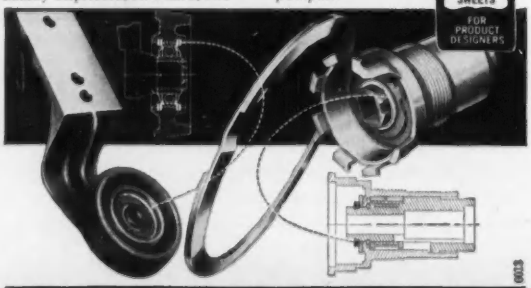

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to 40 per cent, with a frit to pigment and refractory ratio of 3:1, were superior to commercial paints pigmented with metallic powders. Paint characteristics can be widely varied by the addition of zinc dust and/or mica and by variation of the composition and ratios of frits.

Muffler components of various items of engineering equipment were coated with the best experimental paints, and the items were field tested at the Engineer Proving Ground, Fort Belvoir, Va. These field tests verified laboratory results that this type of paint, when applied to clean, sandblasted steel by conventional methods and fused by heat generated within the component, provides a durable, heat-resistant, corrosion-protective film superior to that provided by the conventional olive-drab paint now being used on military equipment. Based on the successful completion of these studies, a procurement specification was prepared.

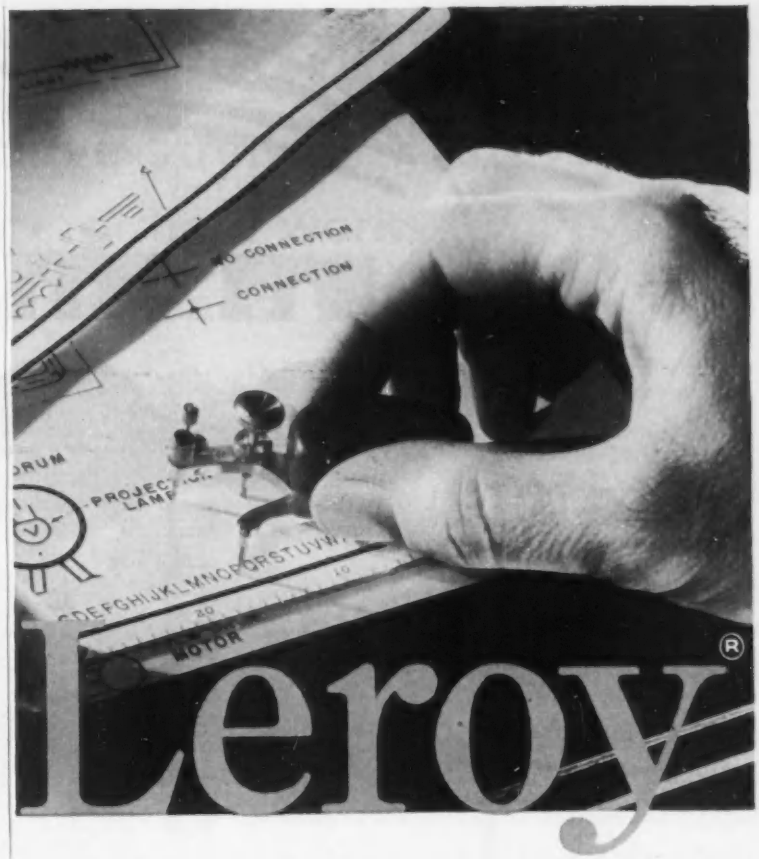
Cost of the paints developed is high; however, over-all reduction of more than 85 per cent in existing maintenance costs can be achieved. The report concludes: a ceramic frit, silicone resin-type paint has been developed which is capable of withstanding temperatures up to 1400 F without significant deterioration or loss of protective properties and which meets other desired military characteristics.

The Structure of Turbulent Shear Flow

A. A. Townsend, *Emanuel College, Cambridge University.* 5½ x 8 *in.*, 315 *pp. Published by Cambridge University Press,* 32 *E.* 57 *St., New York* 22, *N. Y.* $7.50.

This is the first book to attempt a systematic and comprehensive discussion of all kinds of turbulent motion, and the first to provide an analysis of the processes which occur. Turbulent motion is the most important and the least understood branch of fluid dynamics. The theory has traditionally been regarded as an unsolved problem for over half a century; present knowledge of the subject depends mainly on experimental studies during the last 10 yr, and these results are scattered through

(Continued on page 408)



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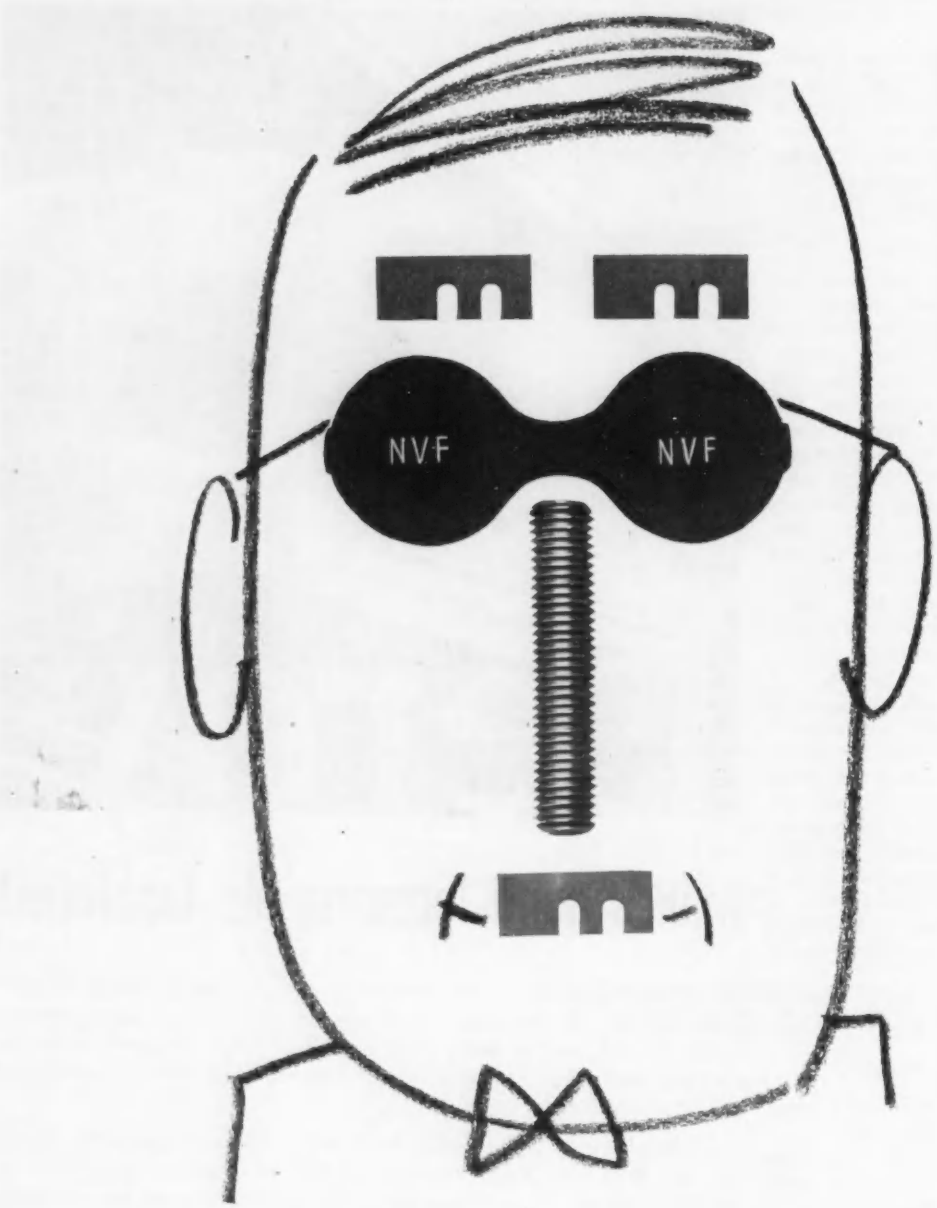

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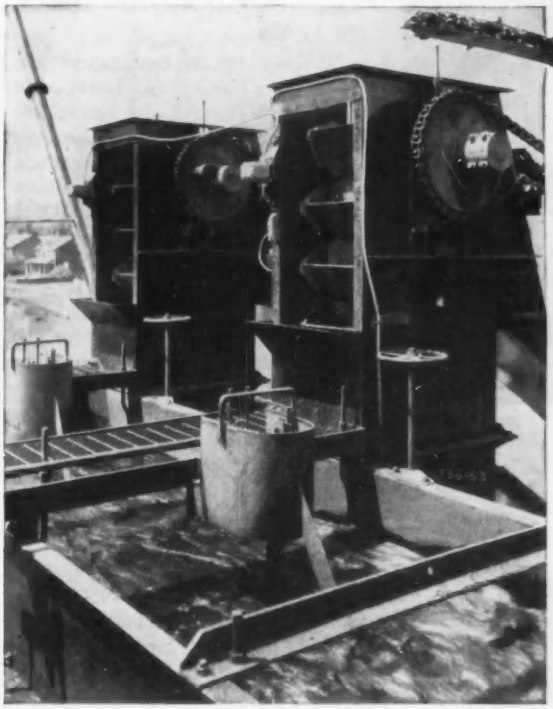
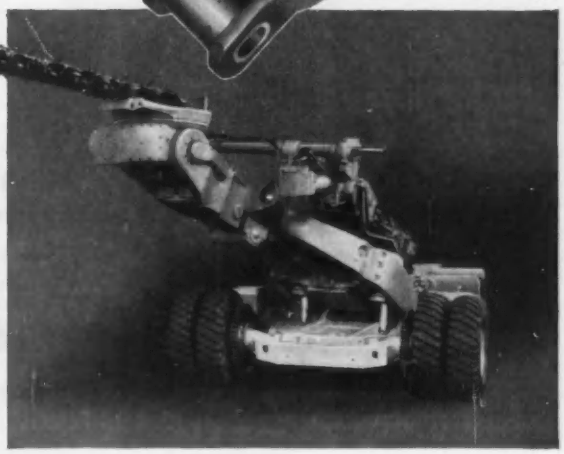
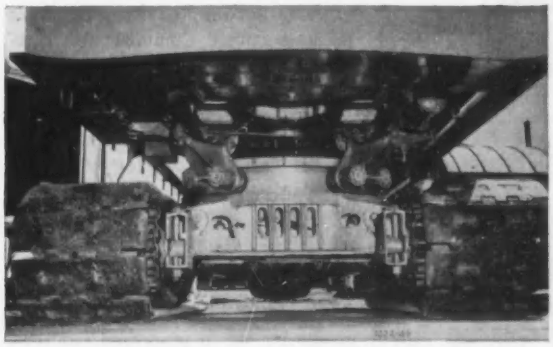


Jeffrey STR Chain on bucket elevator drive of cleaning jig.



Jeffrey STR Chain on traction wheels of large cutter.



Jeffrey STR Chain on crawler drive of power shovel.

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Chromium, Vol. I

ACS Monograph No. 132. Edited by MARVIN J. UDY. *6½ x 9 in., 433 pp. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. $11.*

Written by 30 contributors and edited by a research and development engineer, Volume 1 of a two-volume ACS monograph covers the chemistry of chromium and its compounds. Volume 2 describes the metallurgy of chromium and its alloys. In Volume 1 there appear chapters on the history of chromium, its minerology and geology, chemical and physical properties of its compounds, analytical chemistry, and the manufacture and use of chromium compounds. The two volumes are a series of monographs written by 36 different authors expert in particular phases of the science and technology of chromium.

Electrical Indicating Instruments

NEMA Pub. No. E1 1-1955, Sponsored by Electrical Standards Board. 8½ x 11 in., 48 pp, paper bound. Published by American Standards Association, Inc., 70 E. 45 St., New York 17, N. Y. $2.

This standard, also approved by NEMA, has resulted from the work of the Sectional Committee on Electrical Measuring Instruments, C39. In developing the 1949 revision of the first American Standard on Electrical Indicating Instruments, C39.1-1938, approved by the American Standards Assn. in July, 1938, the committee gave due consideration to the former American War Standard for Electrical Indicating Instruments, C39.2-1944, and incorporated those parts which were applicable to instruments for use in peacetime industrial applications. This specification is intended to assure that instruments conforming to it will be satisfactory

(Continued on page 411)

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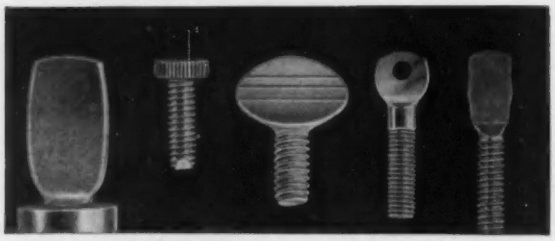

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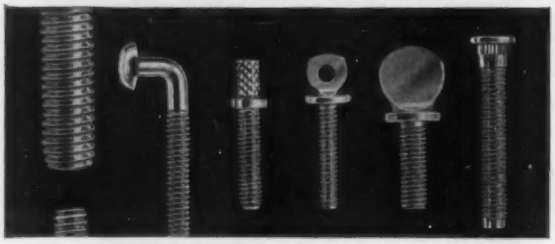

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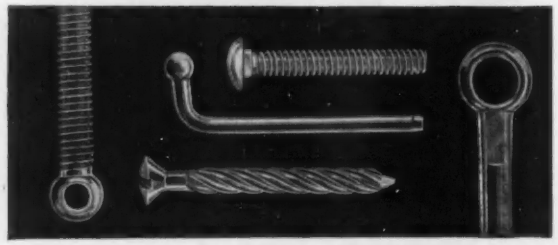

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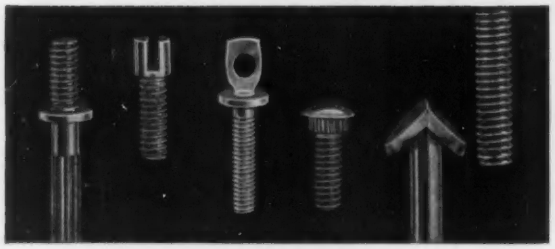

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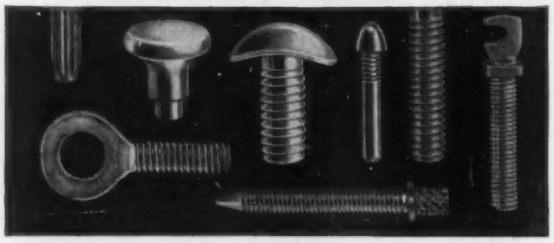

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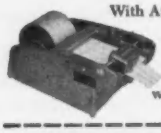

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for general industrial use. It does not necessarily, however, cover all features or special performance requirements of instruments to which some purchasers may wish to give attention.

In the preparation of this standard full recognition was given to the likelihood of improvement, and as change takes place, revisions of this standard will be necessary. The third edition (1951) added the detailed requirements for portable instruments to the second edition which covered panel and switchboard instruments only. Additional definitions and requirements for portable instruments were included, as well as miscellaneous minor changes which were found necessary. In this, the fourth revision, the standard was brought up to date and additions were made covering soldering terminals and insulation tests.

Encyclopedia of American Associations

8¾ x 11¼ in., 306 pp. Published by Gale Research Co., 424 Book Tower, Detroit, Mich. $15.

This is a directory of non-profit organizations of national scope. In most cases, the societies and associations included have been the source of the information provided.

The organization listings are arranged in following sections: trade; business; agricultural and governmental; scientific and engineering; educational and social welfare; health and medical; general; chambers of commerce; a cross-reference index. Information provided in individual listings includes: name of organization, address, chief official, staff, founding date, description of purpose and activities.

Standards On Electrical Insulating Materials

6 x 9 in., heavy paper cover, 656 pp. Published by American Society For Testing Materials, 1916 Race St., Philadelphia 3, Pa. $6.

Sponsored by Committee D-9, the changes since the previous edition issued in 1955 comprise 12 revisions and two new items, covering methods of testing silicone insulating varnishes

(Continued on page 414)

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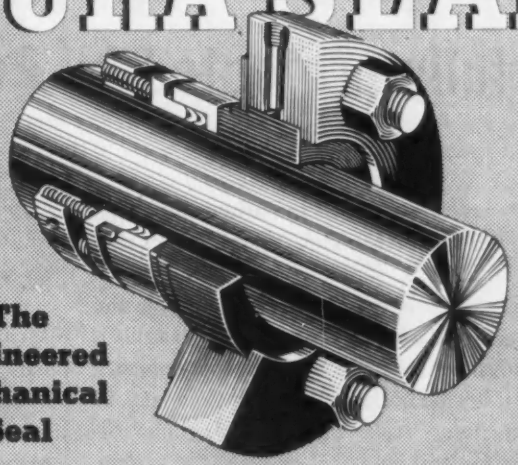

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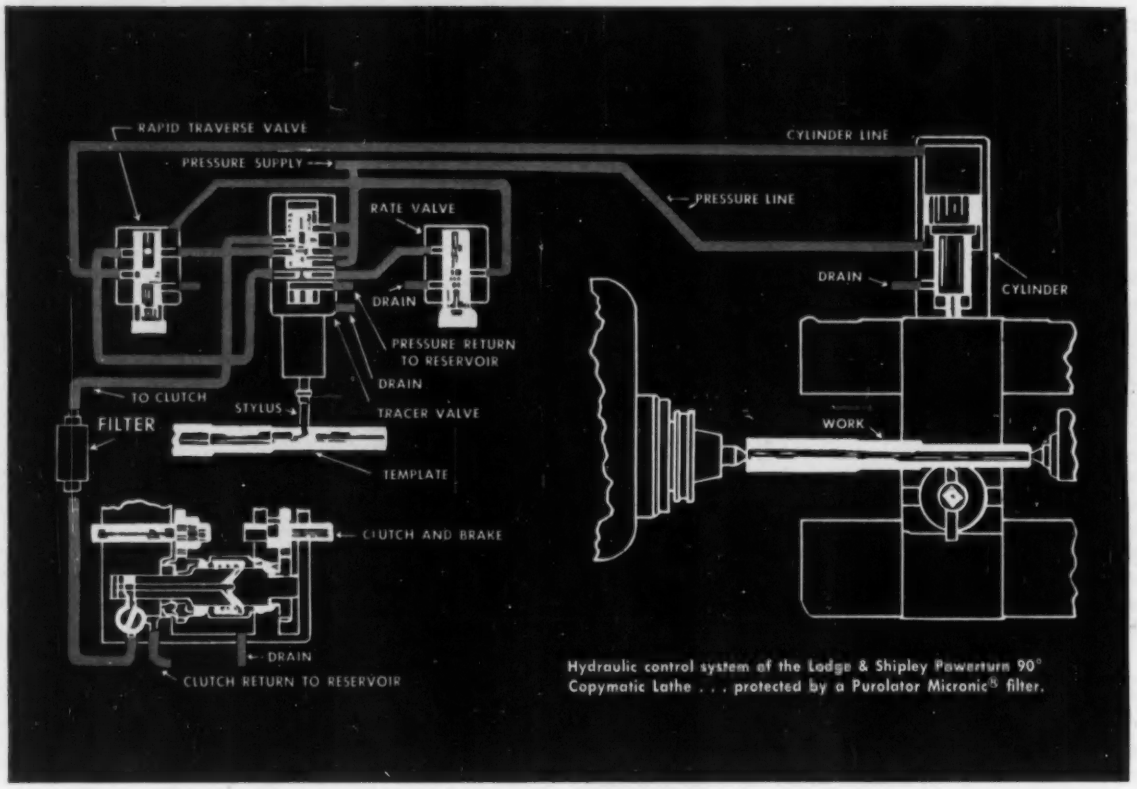

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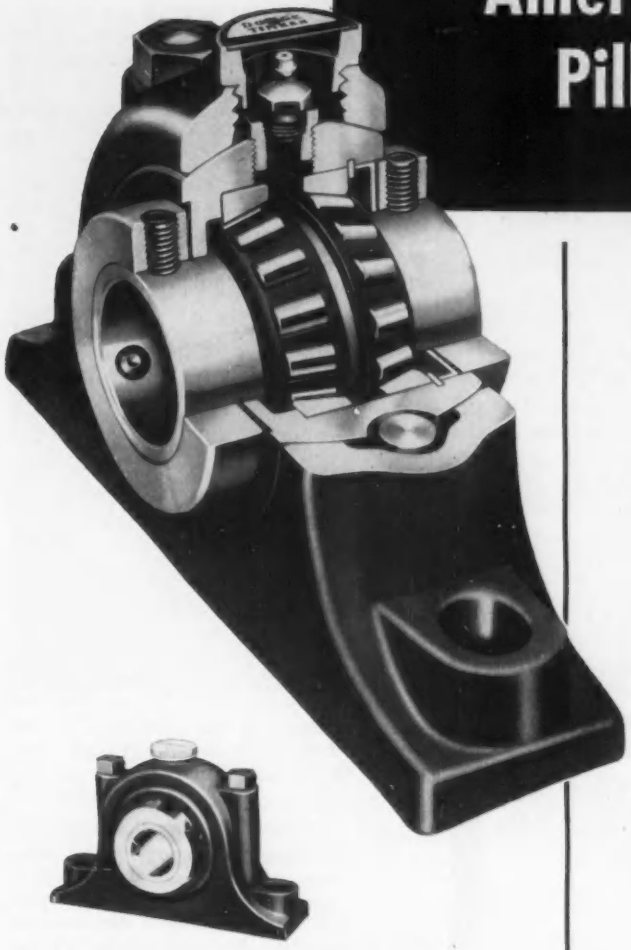

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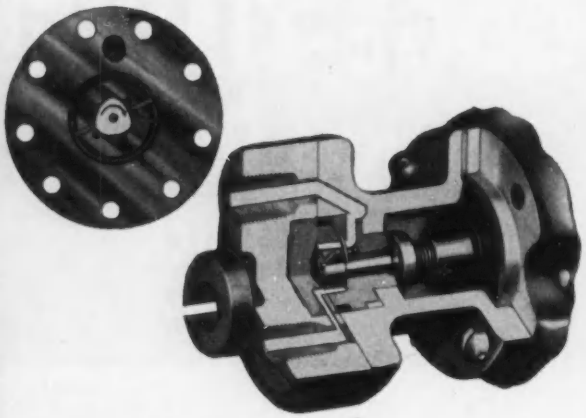

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and a recommended practice for cleaning plastic specimens for insulation resistance testing. The compilation includes 83 methods of test and specifications.

Two appendices give proposed recommendations for writing statements on the usefulness of tests of electrical insulating materials, and proposed methods of test for dielectric constant and dissipation factor of aviation fuels.

Specifications and test methods for the following materials are included: insulating shellac and varnish; plates, sheets, tubes, rods and molded materials; mineral oils for electrical insulation; ceramic products; solid filling and treating compounds; insulating fabrics and papers; mica products.

The compilation also includes a number of electrical tests and conditioning requirements for electrical testing, which are generally applicable to insulating materials.

Computers: Their Operation and Applications

EDMUND C. BERKELEY, *President, Berkeley Enterprises, Inc., and* LAWRENCE WAINWRIGHT, *Consultant.* 6 x 9 *in.*, 366 *pp. Published by Reinhold Publishing Corp.*, 430 *Park Ave., New York* 22, *N. Y.* $8.

Newest developments in both the techniques and equipment of automatic computing are described, illustrated and compared in this book. Emphasis is on practical, down-to-earth information on how these machines work and what they can do. All the basic elements of digital, analog and miniature computers are fully explained, as are such important considerations as computer reliability, advantages, limitations and maintenance.

A large chapter is devoted to present and potential applications of computing machines in scientific laboratories, government, military installations and many business markets. Other valuable features include: convenient checklist of computer characteristics, listing of books, periodicals, papers and organizations offering further information on all aspects of automatic computing machinery; names and addresses of organizations from whom automatic computing equipment may be bought

(Continued on page 417)

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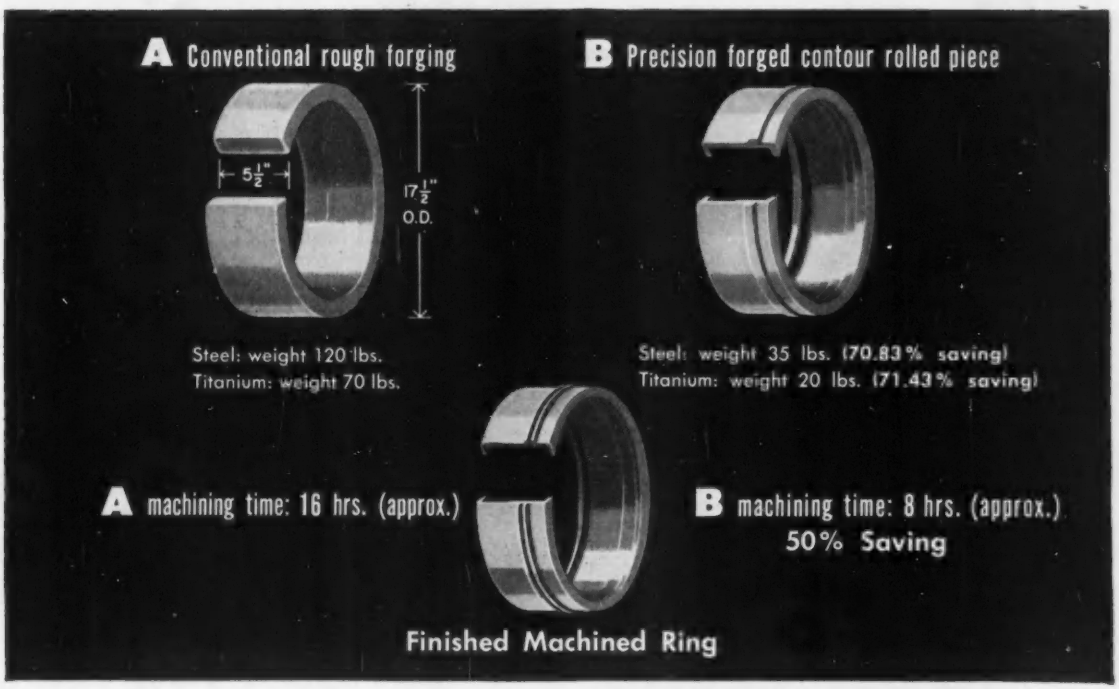
A Conventional rough forging
5½"
17½" O.D.
Steel: weight 120 lbs.
Titanium: weight 70 lbs.
B Precision forged contour rolled piece
Steel: weight 35 lbs. (70.83% saving)
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B machining time: 8 hrs. (approx.)
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WHERE	WHY	HOW
Thread rolling machines	Holding position (leakproof)	Lapped sealing surfaces seal tight indefinitely as a result of wear compensation
Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members—saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) . . . as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

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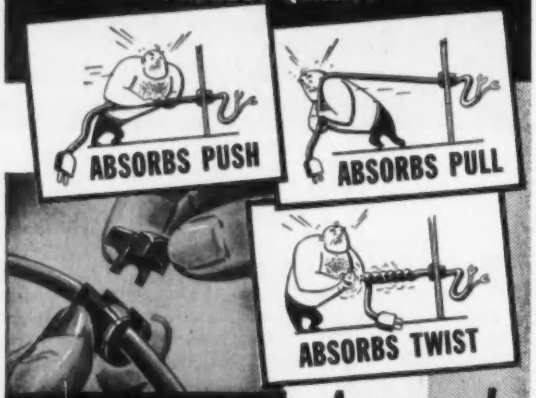

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or rented; large glossary of terms and expressions used in the automatic computing and allied fields.

Engineers, physicists and technicians will find this book packed with details on how these machines are constructed, and may gain many ideas for future development and applications. It is also of interest to business and industrial executives in determining where computers can fit in with their operations and how they can be obtained.

Plane Trigonometry

E. RICHARD HEINEMAN, *Professor, Texas Technological College.* 6 x 9 *in.*, 167 *pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y.* $3.75.

This book should prove especially beneficial to readers who have a weak mathematical background. Trigonometric functions and identities are defined and clarified before going on to the discussion of logarithms, the solution of triangles, inverse trigonometric functions and complex numbers.

Miscellaneous points include: applied problems; problems that are encountered in calculus; the concept of infinity; memory schemes; and the uses of sine and cosine curves.

A Study of Piezoelectric Elements for The Measurement of Transient Forces

PB 111702, YUSUF A. YOLER, HENRY T. NAGAMATSU, *California Institute of Technology.* 8 x 10½ *in.*, 27 *pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.* $1.

The suitability of various piezoelectric crystals for the measurement of transient forces is surveyed in this publication. This is done by comparing the "figure of merit," which is proportional to the static charge produced by a unit stress, for crystals which are otherwise satisfactory with respect to effect of temperature, humidity, brittleness, and natural frequency. Equations determining the output and the "response time" of a pickup are presented. The advantages of stacking

(Continued on page 420)

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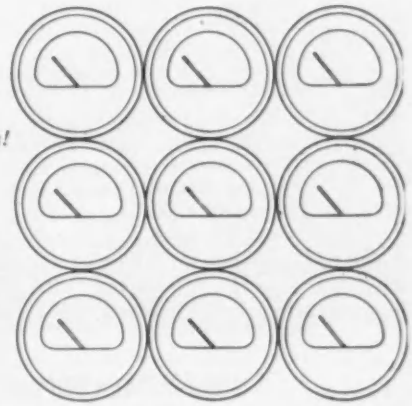

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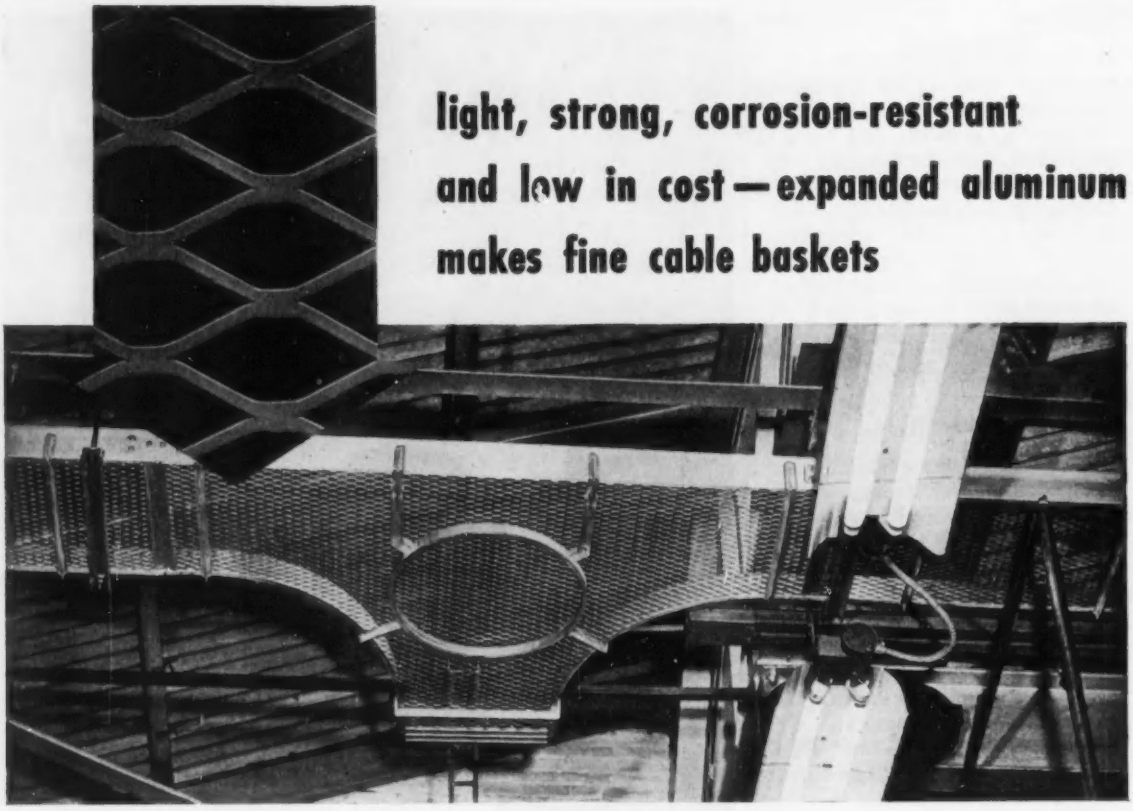

Add up the advantages of Penmetal expanded aluminum and you can see why Husky Products, Inc. uses it for their line of cable baskets.

The extreme lightness of expanded aluminum . . . 80% lighter per square foot than the original sheet . . . makes the baskets easy and economical to handle and erect. Yet with plenty of strength to take the weight of the cables—thanks to the diamond truss pattern.

Corrosion-resistance makes for durability; sustained clean appearance. Low cost means large areas can be covered economically. Finally, expanded aluminum is easily cut or shaped or welded.

Cable baskets are another example of the profitability of Penmetal expanded aluminum. Take advantage of it in your designs and in your selling. Further details? Ask for folder 507-EM.

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Penmetal

PM-105

The Baskets in the photos carry electric cables in power plants, industrial installations, etc. They were made from Penmetal ¾" flattened expanded aluminum—by Husky Products, Inc., Cincinnati, Ohio

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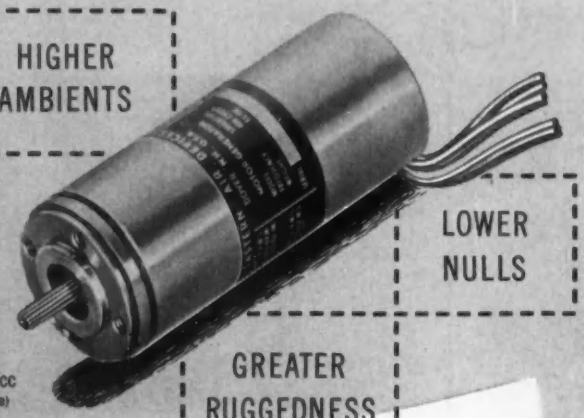

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the crystals in parallel to increase the figure of merit are shown.

The application of piezoelectric elements to measure normal forces, shear forces, and volume expansion forces is also discussed. Advantages of recently developed ceramic elements over natural crystals for the measurement of normal forces and volume expansion are indicated. Natural crystals must be used to measure shear forces. Tables showing the properties of various crystals for measuring normal forces and shear forces are presented.

Analysis and Design of R-C Phase-Shift Oscillator Networks

PB 102595, NRL Report 3676, Naval Research Laboratory. 10½ x 8½ in., 115 pp. Available from U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C. $3.

Much industrial electronic equipment uses vacuum-tube oscillators for generation of sonic, supersonic, or r-f energy. One important basic type is the phase-shift oscillator, a resistance-capacitance tuned oscillator normally employing three or more L-sections in cascade. The frequency of oscillation may be uniquely determined and expressed as a function of the network parameters.

In recent years various papers have been published concerning resistance-capacitance phase-shift oscillators, most of which discussed rather specific or novel circuits. Among the first papers only the basic circuit was discussed; its simplicity as a stable low-frequency sine-wave oscillator using only one tube was indicated. Other points brought out were compactness, lightness, and low expense of building such oscillators, since they contained no transformers and only a few resistors and capacitors. As time passed, the requirements for oscillators of this type increased and innovations of the basic network were investigated.

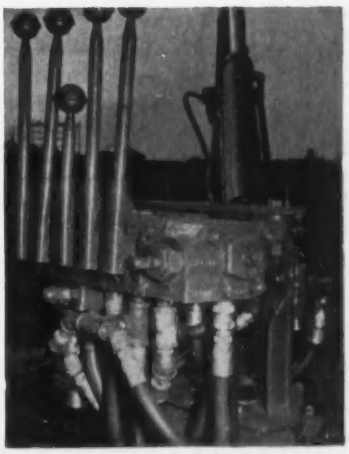
Frequency deviation, frequency stability, and harmonic content in r-c phase-shift oscillators are investigated by means of general equations derived for the three- and four-section network types. Network tapering

(Continued on page 423)

25% Larger capacity valve gives faster action to backhoe

The main valve on all Henry Hydraulic Backhoes is the new Commercial "Performance Rated" TB05 series.

Chosen because it has a greatly reduced *back pressure* this valve is teamed up with a pump having greater discharge than was in former use. Much faster action of the backhoe results and this is most important to a contractor who must keep working on schedule.



Three point suspension positions new tandem valve. Operator easily controls directional flow of fluid power to operate backhoe attachment.

Because of the parallel circuit built into these valves, simultaneous operation of two or more cylinders makes digging and load discharge one smooth continuous operation.

Consisting of an inlet section, five working sections and the outlet section, this tandem valve controls the operation of the cylinders which actuate the boom, swing, lift, crowd and bucket. The built-in combination safety relief-pressure control gives safety protection to the entire hydraulic circuit and prevents overloading the structural members of the equipment. The design of these new valves makes it a simple matter to incorporate special feature valves to give plus values to the equipment.

"Henry" mounts directly below this valve a swing cushion valve which smooths out the action of the boom as it comes to the end of its swing. This takes the shakes out of the equipment and reduces its wear and tear, thus lengthening service life of the equipment.

Service problems and breakdowns are minimized because the sectional feature of the tandem valve permits servicing in the field of any one section and does not require replacement of the entire valve.

Henry Manufacturing Company says, "We feel that Commercial valves have contributed to the dependability and performance which has accounted for many sales of our equipment when demonstrated against competitive machines."

You, too, will find that these new "Performance Rated" valves will improve your equipment's salability. Write to Dept. G-44, The Commercial Shearing and Stamping Company, Youngstown, Ohio, for the Performance Data which will show you what goes on inside these valves.

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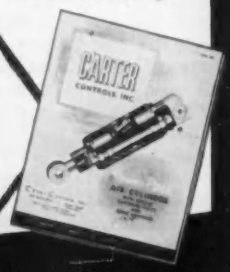

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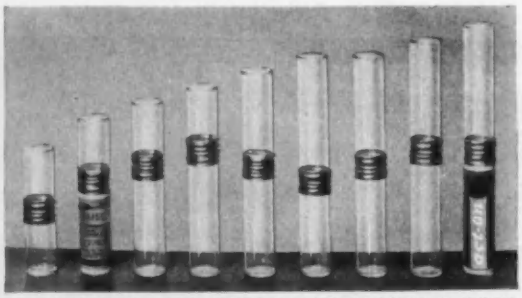

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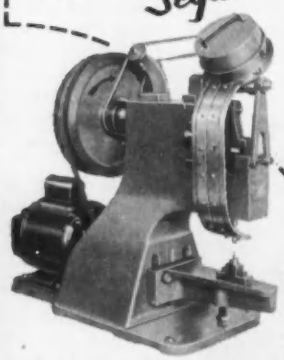

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factor and individual section resistance variation effects are shown by curve families.

A zero phase-shift network that offers flexible circuit design is described. The accompanying design curves developed by analysis of the general equations are useful in the design of phase-shift oscillators for optimum values of frequency deviation, linearity, frequency stability, harmonic content, and amplitude modulation, as determined by their application. The design of an oscillator to meet specific characteristics is illustrated.

Evaluation of High Strength Weldable Titanium-Base Alloys

PB 121069, C. R. Lillie, *Armour Research Foundation for WADC, 8 x 10½ in., 62 pp. paper-bound. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C., $1.75.*

Six Ti-Al-V alloys were investigated for suitability as high strength weldable sheet at high temperatures. All sheet material were capable of heat treatment to a strength-weight level competitive with stainless steel. The alloys were weldable and good formability was indicated. Favorable properties were retained after preparation with commercial quality sponge meterial and heat treatment at commercial standards. The best compositions lay in the range of Ti-4Al-4V to Ti-6Al-4V.

Scaling of Titanium and Titanium Alloys

PB 121219, 8 x 10½ *in.*, 110 *pp, paper-bound.* H. J. Siegel, R. C. Duncan, Jr., R. E. Swift, *Dept. of Mining and Metallurgical Engrg., University of Kentucky. Available from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D. C.* $2.75.

Preliminary study of the scaling characteristics in air of 36 experimentally produced Ti and Ti-base alloy samples at temperatures of 1200, 1400, 1600 and 1800 F for 4 to 300 hr. Scales formed on all alloys at 1600 F were studied by x-ray diffraction.

(Continued on page 426)

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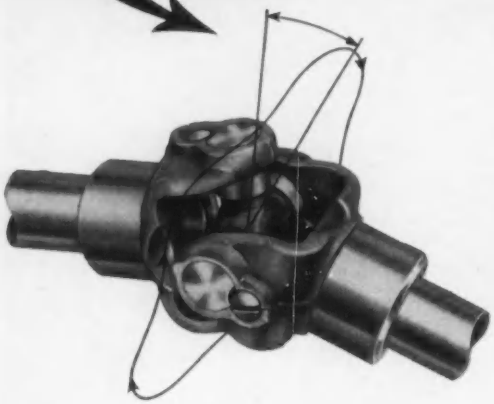

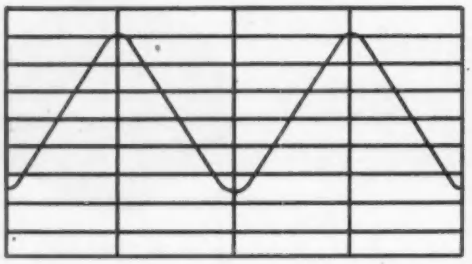

During rotation at a given angle, pin or slipper-type joints speed up, slow down twice during one revolution, as shown by the solid line in the graph.

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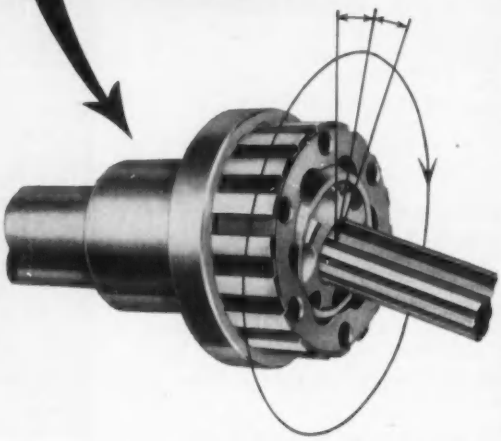

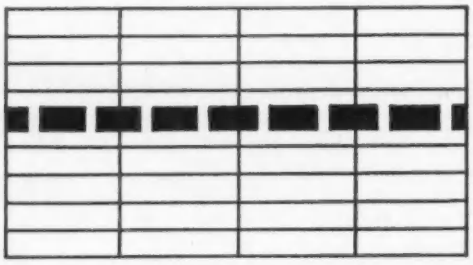

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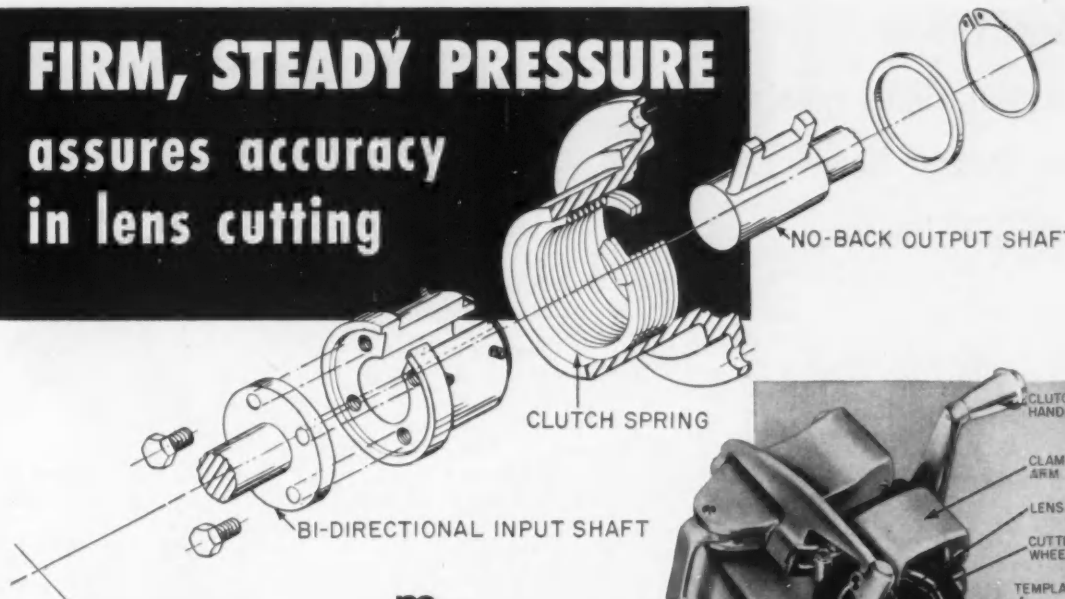
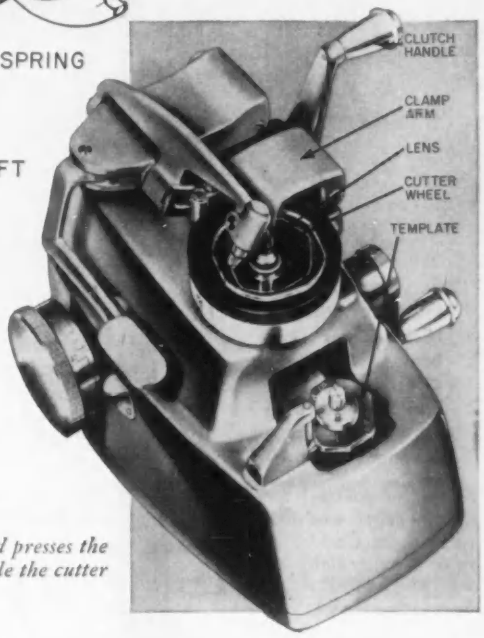


Exploded view of Marquette PrecisionSpring Bi-directional No-back Clutch in American Optical M-542 Lens Cutter



A turn of the clutch handle lowers the clamp arm and presses the lens firmly against the lens pad. The lens revolves while the cutter wheel, guided by template, cuts it to exact shape.

This Marquette PrecisionSpring Clutch provides constant and uniform pressure, with minimum back-lash. It assures dependable, trouble-free performance—and saves the operator's time.

The input shaft can be rotated in either direction, and drives the output shaft in the same direction at the same speed. But when torque is applied to the output shaft (either clockwise or counter-clockwise) the clutch will lock securely and the output shaft will not rotate.

Marquette Spring Clutches have given dependable service for many years in a wide range of applications—from Aircraft to X-ray. They require very little space. They maintain their efficiency almost indefinitely. And they cost much less than other types of clutches.

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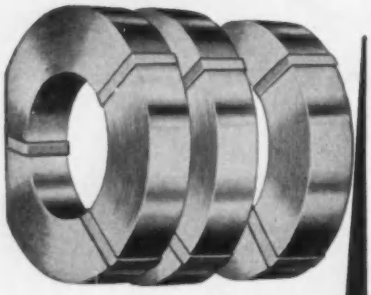

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Scaling propensity of Ti-base alloys relative to unalloyed Ti is evaluated according to weight gain with time. An investigation of gaseous penetration in the commercial materials RC-70, RC-130A and RC-130B made at 1600 and 1800 F is included.

The Steel Skeleton, Vol. II: Plastic Behaviour and Design

J. F. BAKER, *Head, Dept. of Engineering;* M. R. HORNE, *Assistant Director of Research;* J. HEYMAN, *Lecturer, University of Cambridge, Cambridge, England.* 7½ x 10½ *in.*, 408 *pp. Published by Cambridge University Press, 32 E. 57 St., New York 22, N. Y.* $12.

Vol. I of *The Steel Skeleton* covered elastic behavior and design of steel structures, describing the experimental investigations of the Steel Structures Research Committee. Vol. II, *Plastic Behaviour and Design*, describes the investigations of structure design in the plastic range.

Because some parts of a structure pass out of the elastic into the plastic range, experimental investigations discovered that orthodox methods of structural design did not fully exploit the qualities of steel as a building material. Vol. I concluded that the elastic behavior of building structures was too complicated to form the basis of a really comprehensive design method. These investigations have led to a much simplified design method, and the direct and most economical design of portal frames is now possible.

Vol. II devotes particular attention to instability of structures. Behavior up to collapse of continuous stanchions is described and a design method for multi-story welded frames outlined. Recent buildings designed plastically are also described.

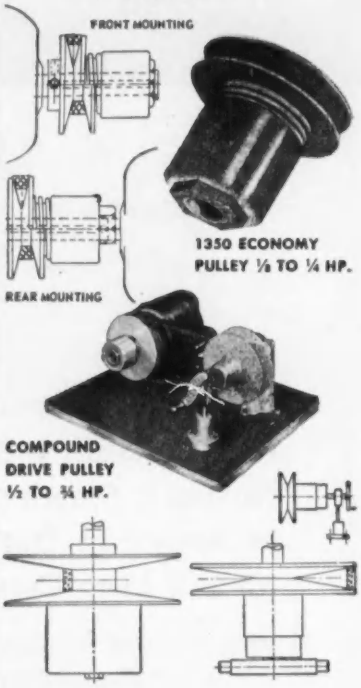
Engineering as a Career

RALPH J. SMITH, *San Jose State College, 6 x 9½ in., 365 pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y.* $4.75.

To fill the ever widening gap between industry's requirements for engineers and the number of engineering

(Continued on page 429)

Lovejoy
Fractional Horsepower
VARIABLE SPEED PULLEYS



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low in initial cost . . . easily installed on old or new equipment.

Minimum Maintenance—
simple construction assures trouble-free operation . . . lifetime lubricated with oil-impregnated bronze bushings.

Constant Belt Alignment—
inner and outer pulley sheaves open equally to provide smooth, infinitely variable speed ratios to 8 to 1.

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Sure grip of belt sides delivers full traction under all load conditions...result is greater horsepower carry capacity.

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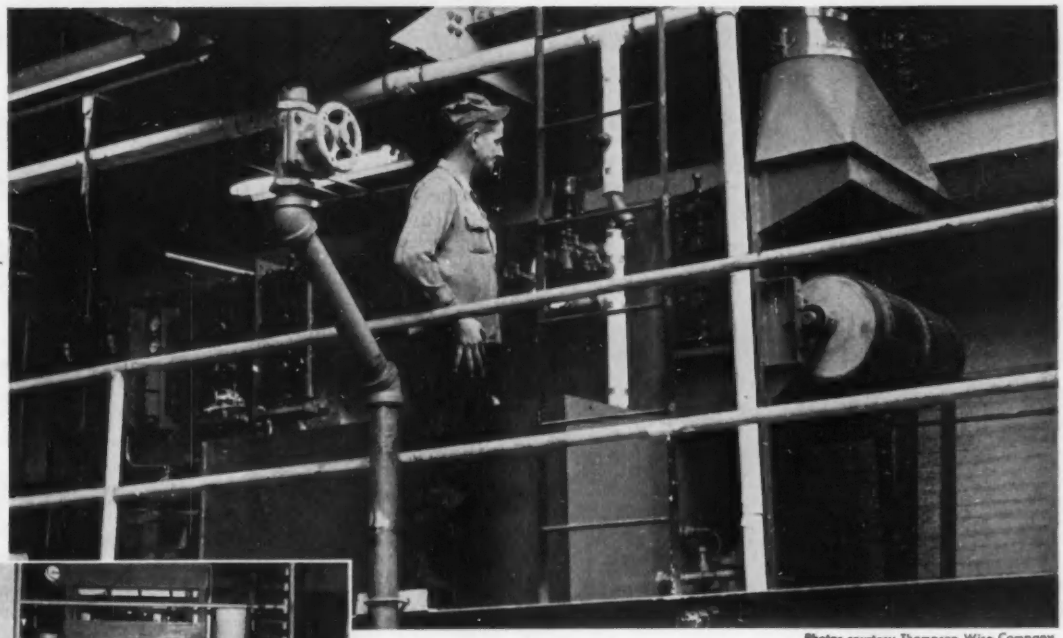
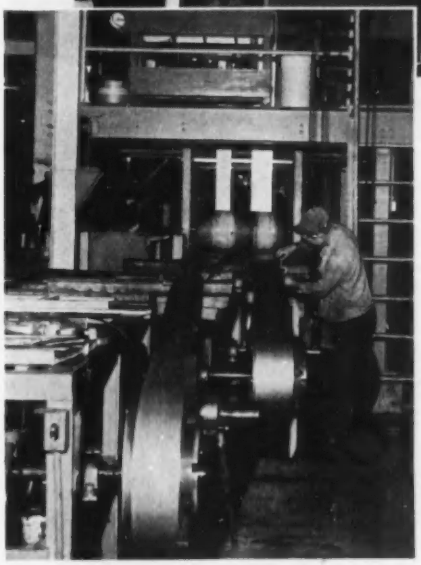


Photos courtesy Thompson Wire Company



Above (right)—In this continuous installation, strip steel is treated with Bonderite, then with Bonderlube lubricant. *Below*, treated strip is re-coiled as it comes out of the machine, Bonderite-Bonderlube treated.

Successive steps in forming a small case from Bonderite and Bonderlube treated strip.

For better performance in the forming dies . . .

Get steel strip, mill-treated with

BONDERITE *and* BONDERLUBE

Here's a service that can mean real savings in your cold forming operations. Buy mill-treated steel, in coils, treated with Bonderite and Bonderlube and ready for the dies.

This specially treated strip, with its Bonderite-Bonderlube coating, is used for many products and components made by cold forming. The combination of Bonderite and Bonderlube provide such effective lubrication that severe deformations are possible without marring surface finish. Tools and dies last longer, production may be greatly increased, production costs are reduced.

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**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

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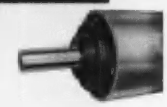
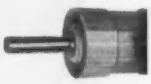
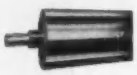


Wood rolls for wet or dry service



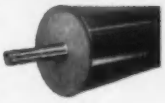
Stainless steel rolls



Teflon and other plastic rolls

Tube rolls, any metal

Chromium plated steam and cooling rolls



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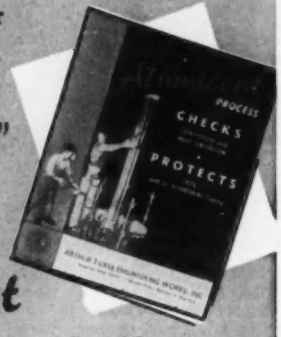

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graduates, educators have suggested a program to inform high school students about engineering as a course of study and as a career. Here is the first attempt at a systematic presentation intended to explain the nature of engineering, describe the work of professional engineers, and indicate the requirements for success in the profession.

Intended as a text for an orientation course for freshmen students, the author first describes the engineering profession, its history and functions. In the second section the engineering curriculum is covered to better acquaint and guide the beginning student in subject coverage and tools and methods of problem solution. In the last section a preview of basic engineering sciences (mechanics, thermodynamics, electrodynamics, engineering economy) is included to give the reader a practical, if elementary, concept of the fundamental laws with which he will be working.

Engineering Formulas and Tables

5 x 7¼ in., loose leaf or paper cover, 350 pp. Published by Lefax, Sheridan Bldg., Ninth & Sansom St., Philadelphia 7, Pa., $2.75.

Contains 350 pages of basic formulas, design data, and tables. Condensed, indexed and mathematically accurate, division sheets with printed tabs furnish access to the particular information desired. Sections include mathematics, measures, materials, gages, screws, mechanics, electricity and magnetism, hydraulics, structural data, reinforced concrete, pipe and fittings, steam tables and mathematical tables.

Mathematics for Electronics with Applications

HENRY M. NODELMAN, *Polytechnic Institute of Brooklyn*, FREDERICK W. SMITH, *National Broadcasting Co.*, *9½ x 6¼ in., 391 pp. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y. $7.00.*

This book correlates engineering practice and mathematical topics of importance to the electronics field.

(Continued on page 432)

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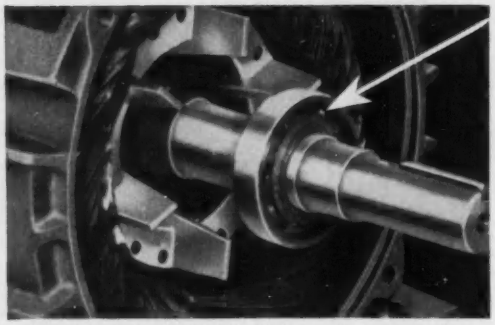
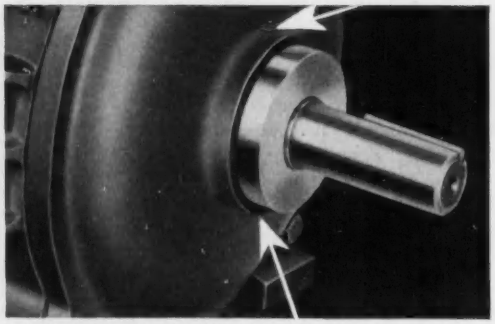
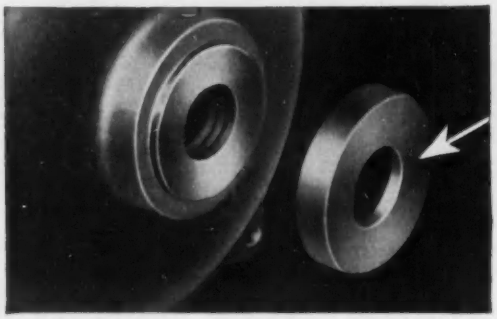
Wagner ELECTRIC MOTORS...the choice of leaders in industry



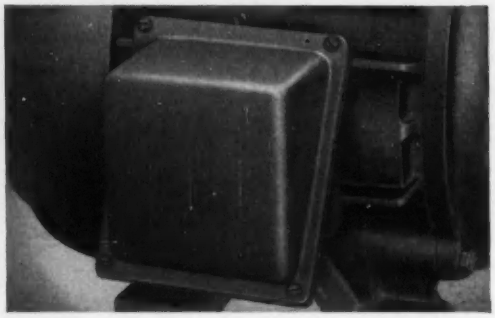
HEAVY-DUTY BALL BEARINGS—Highest quality bearings of more than ample capacity to carry heavy loads provide long trouble-free service.



BEARINGS CAN BE RE-LUBRICATED—These Wagner motors can be re-lubricated when necessary to prolong bearing life. New grease can be added—old grease removed through openings provided in top and bottom of bearing housing.

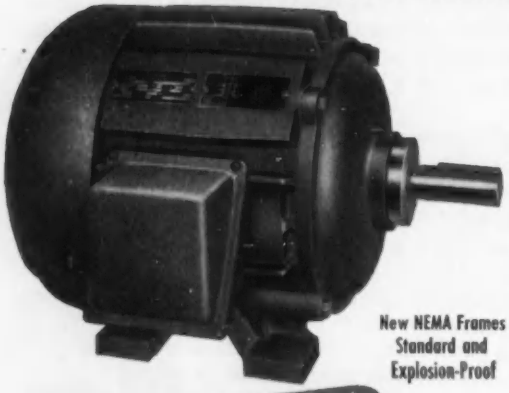


BEARINGS STAY CLEAN—Both ends of these motors are equipped with running shaft seals to keep dirt, dust and water from the bearings. There's no grease loss because bearing housings have effective seals to prevent escape of grease.



EASY TO CONNECT—Large diagonally-split conduit box which can be mounted in any of four convenient positions, provides ample room for making connections. Leads are readily identified by numbers stamped on the terminal bushing.

Wagner totally-enclosed motors mean less down-time for machine tools



New NEMA Frames Standard and Explosion-Proof

Wagner totally-enclosed fan-cooled motors are particularly suitable for use on all types of machine tools.

They are fully protected against damage from steel filings, chips, dust, dirt, fumes and moisture. They require no maintenance other than periodic lubrication.

If appearance is a factor, you'll find that the pleasing proportions of these motors give them that functional beauty obtained only when the design is fundamentally *right*.

Ribs on the corrosion-resistant cast iron frames add mechanical strength and increase the surface area for more efficient cooling. Full information and principal dimensions are given in Bulletin MU-203 which is yours for the asking.

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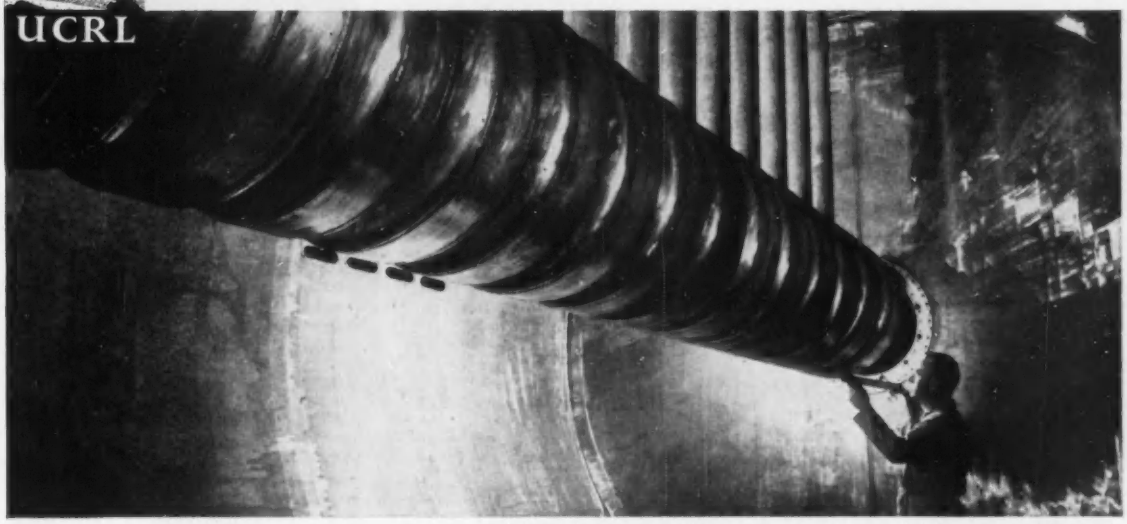

At UCRL's Livermore, California, site—interior view of drift tubes in high-current linear accelerator designed to deliver 250 ma of 3.6 Mev protons or 7.8 Mev deuterons

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New techniques... new equipment... new knowledge—all are in constant growth at Livermore and Berkeley, California as some of America's most challenging nuclear frontiers are met and passed by the University of California Radiation Laboratory's unique scientist-engineer task force teams.

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The presentation is different from other available texts because of extensive correlation between mathematical theory, which has generally been treated from a classical point of view, and the practical application.

Recent advances covered in the electronics field include transistors, the matrix method of network analysis and dimensional analysis of electronic problems, including a discussion of the mks system of units. Up-to-date exercise problems based on actual current industrial engineering practice are included. All mathematical applications are accompanied by examples and supported with references.

Criteria for Professional Employment of Engineers

5½ x 8½ *in., booklet, paper-bound, cover, 23 pp. Published by National Society of Professional Engineers, 2029 K St., N. W., Washington 6, D. C., $0.25.*

Printed in check-list format, the booklet covers specific categories of engineering career development. The criteria included suggest the responsibilities of the employer to his professional employees, and the latter's responsibilities to the employer. Topics included are recruitment, indoctrination, professional development of the individual, salaries, engineering titles, personnel practices, and termination policies.

Modified 12 Per Cent Chromium Steels for Intermediate Temperature Applications

PB 121226, 8 x 10½ *in., 23 pp, paper-bound.* P. Shahinian and J. R. Lane, *High Temperature Alloys Branch, Metallurgy Div., Naval Research Lab., Washington 25, D. C. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $0.75.*

Development by the Navy of a useful 12-per cent chromium steel modification without columbium is described in a report of recent research released for industry use. The research was part of continuing investigations into replacement of austenitic steels by ferritic grades for high-stress,

(Continued on page 435)

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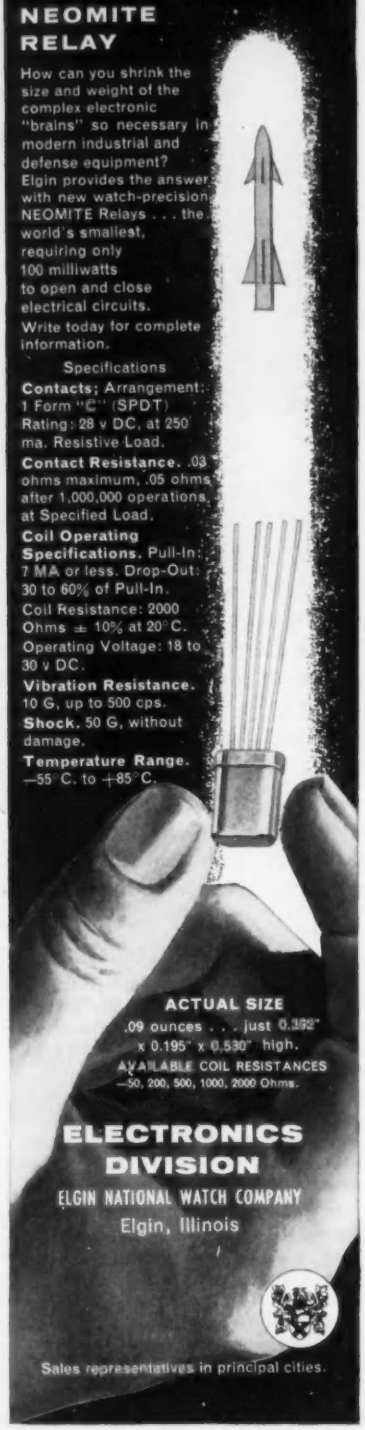
Coil Operating Specifications. Pull-In: 7 MA or less. Drop-Out: 30 to 60% of Pull-In.
Coil Resistance: 2000 Ohms ± 10% at 20°C.
Operating Voltage: 18 to 30 v DC.
Vibration Resistance. 10 G, up to 500 cps.
Shock. 50 G, without damage.
Temperature Range. —55°C. to +85°C.



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.09 ounces . . . just 0.382" x 0.195" x 0.530" high.
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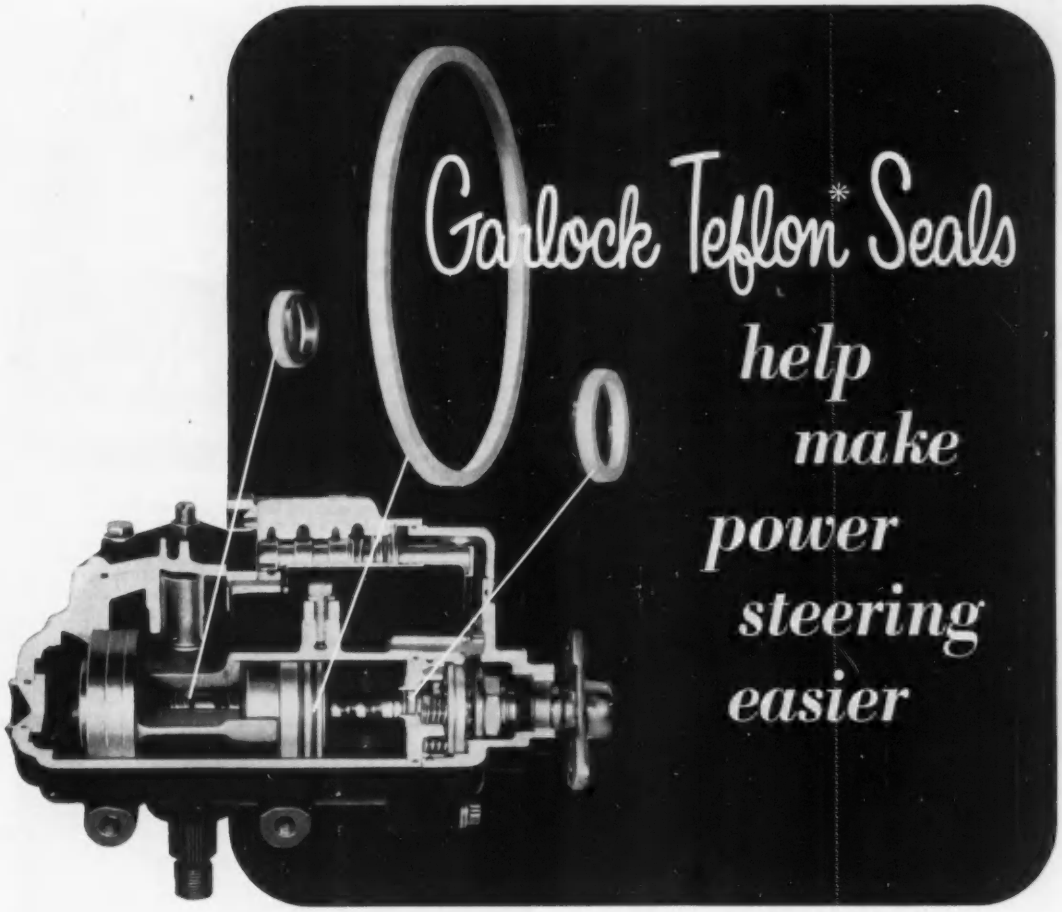
MORE OF THE GARLOCK **2,000**



The low coefficient of friction and longer service life of Garlock Teflon seals has been used to great advantage by a large producer of power steering equipment. The switch to Teflon substantially reduced both manual turning effort and wear in the power steering mechanism.

These seals were designed by Garlock engineers to do a particular job better. They are typical of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet every conceivable need . . . the *only* complete line available. That's why your Garlock representative can give you *unbiased* recommendations. Call him at the start of your next project, his experience will save you time and money. Write today for new Garlock Teflon Catalog AD-155.

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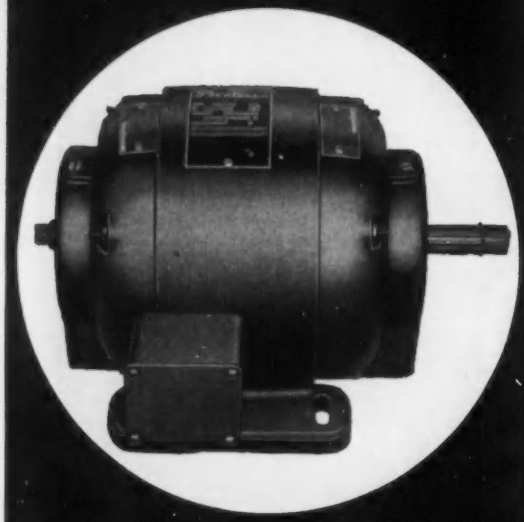

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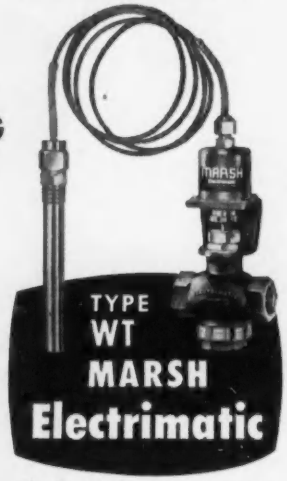

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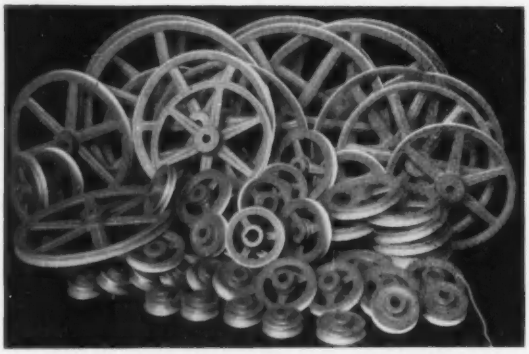

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elevated-temperature applications. Modified 12 per cent chromium steels have received considerable attention, particularly for use in steam and gas turbines.

The report describes creep-rupture properties of the 12 per cent grade modified by additions of molybdenum, vanadium, columbium, titanium and carbon. Tests were conducted at 1100 and 1200F for materials as-cast, cast and homogenized, forged and normalized, and forged, normalized and tempered. Room temperature properties also were determined.

Among other results reported, a modification containing 1 per cent molybdenum and 0.7 per cent vanadium showed creep-rupture properties which compared favorably with the best of the columbium-free alloys developed so far.

Theory of Plastic Plates

PB111943, by W. PRAGER, Brown University for ONR, 8 x 10½ in., 24 pp, paper-bound. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D C., $0.75.

The work reviewed in this publication is a first step toward a consistent theory of perfectly plastic plates, a subject somewhat neglected in recent treatises on plasticity. Problems concerning circular plastic plates under rotationally symmetric conditions of loading and support are discussed and experimental correlation is presented. The report serves as an introduction to a number of recent detailed papers and reports on the subject, some of which are not readily accessible.

Applied Thermodynamics

RICK A. DENNING and NATHAN M. KANE, 9 x 11¾ in., 89 pp. Published by Pelex Publishers, Inc., 149 Broadway, New York 6, N. Y., $4.00.

This book is not a formal textbook on thermodynamics but is written primarily for use by engineers reviewing for their New York State professional engineering examination. It is a summary of working parts on the subject of thermodynamics and includes (1) combustion and compression flow, (2)

(Continued on page 439)

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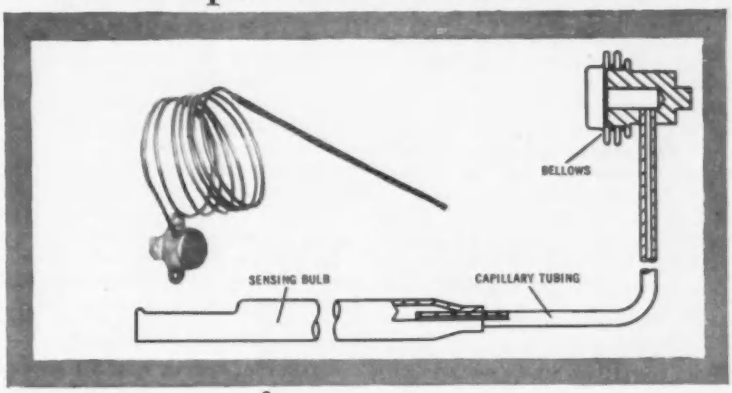

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Tips on specifying timer accuracy

Facts you should be aware of when selecting a timer to meet your accuracy requirements

The application for a timer generally determines the kind and degree of accuracy needed.

If frequent changes are made in the timed interval, setting accuracy is most important. If a machine operation or process occurs again and again at the same timer setting, repeat accuracy is the critical factor. If a timer is factory set for, and operates continuously at, one specific interval, inherent timer accuracy is most important.

Each of these three major types of timer accuracy — inherent, setting, and repeat — calls for different design and manufacturing techniques:

INHERENT ACCURACY

A major factor limiting inherent accuracy is the drive motor. This must (1) be quick starting, (2) be free from coasting, and (3) operate only at synchronous speed. Permanent-magnet synchronous motors meet these requirements better than ordinary clock-type hysteresis motors.

Clutching on a high-speed shaft, close to the drive motor, also increases inherent timer accuracy. High-speed clutching — though more complex and costly than low-speed — should be used on timers in which high accuracy is paramount.

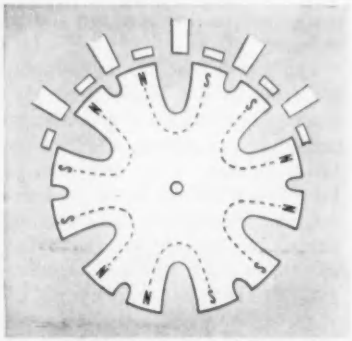
SETTING ACCURACY

Length of dial scale, scale divisions, style of pointers, parallax and distortion due to cover glass, and skill of operators are obvious influences on setting occuracy.

Setting may be of either the friction or vernier (or worm) type. The latter provides good setting accuracies, but lacks the speed and convenience of the friction method. Human errors can often be completely eliminated by use of a factory-set timer.

REPEAT ACCURACY

Shock of operation of a fast reset mechanism — or shock from other causes — can change the timer setting, resulting in inaccurate repeat cycles. This is most likely when the reset and setting mechanisms are combined for reasons of cost. However, by careful design, speed of reset and resistance to shock can be optimized to give the best repeat accuracy.



PERMANENT-MAGNET rotor of Cramer motor (shown here schematically) reaches synchronous speed within two cycles (0.033 sec. at 60 cps) after field is excited, does not coast after power is removed. Most powerful and accurate timing motor available for its size and price.

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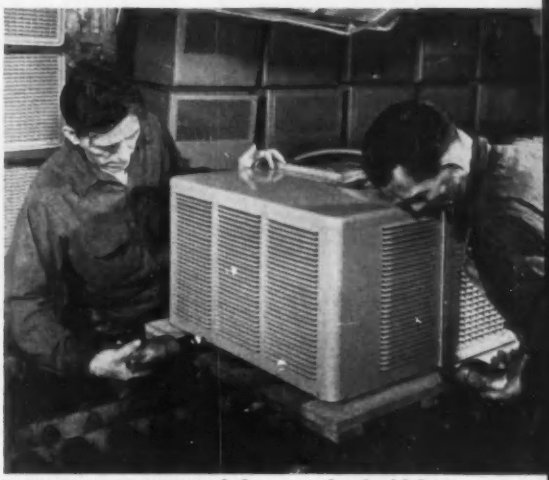
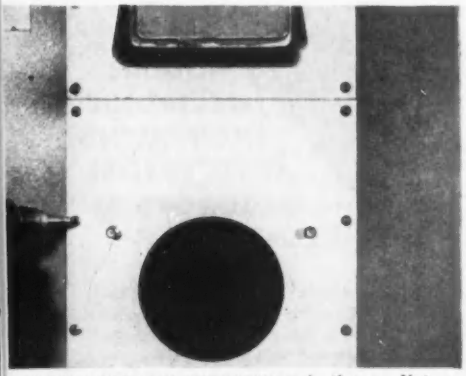


"PHILLIPS HEAD SCREWS help us maintain highest quality and quantity," states Mr. W. E. Zielonka, plant manager of the Fedders-Quigan Corporation, Buffalo, N. Y., makers of famous Fedders room air conditioners and other products. Mr. Zielonka continues: "Our assembly line employees are the best salesmen for Phillips screws. They're paid by piece work, and fast, non-slip driving of screws means a lot."



"IDEAL FOR OUR OPERATION," is the verdict on Phillips screws at the Indianapolis plant of the Bryant Division of Carrier Corporation, world's largest producers of automatic heating units. "Phillips screws are terrific time savers, cause less waste and damage and give much tighter fit," reports Mr. Al Barnett, foreman of the Bryant general assembly department.

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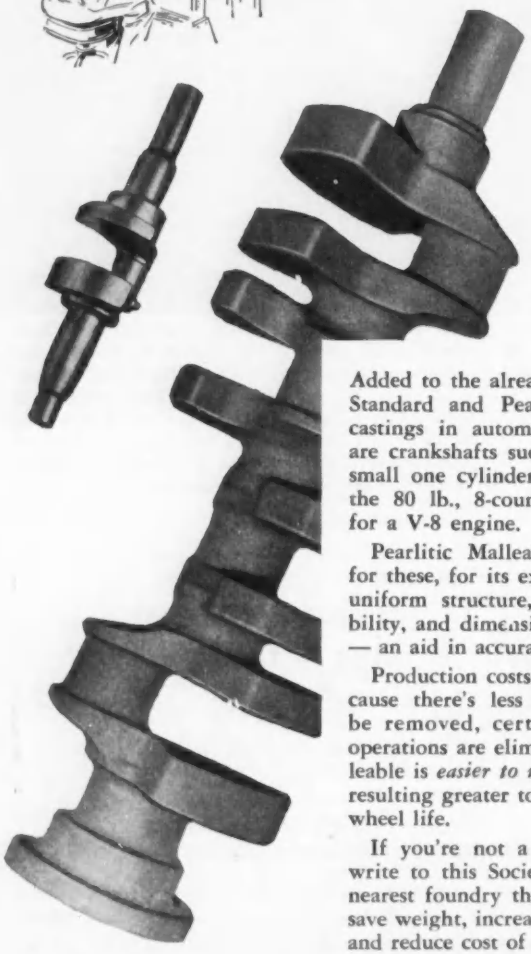

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Handbook of Tubes and Semiconductors

6 x 9 in., 207 pp., Published by TechRep Div., Philco Corporation, 18 & Courtland St., Philadelphia 40, Pa. $2.00.

This manual is composed of six sections, one of which is devoted to servicing and maintenance aids, and service hints which are normally acquired only with experience. Characteristics and connections of about 2000 tubes and semiconductors are included in this book. Tube information includes data on receiving, transmitting, and a variety of special-purpose tubes such as cathode-ray, klystron, magnetron, TR, ATR, hydrogen thyratron, voltage regulator, and voltage reference tubes.

The section on semiconductors lists 450 crystal diodes, microwave crystal diodes, and transistors together with currently available characteristics.

Dynamic Response in Three Dimensions of Linear Elastic Structures

PB 121094, Ralph E. Blake and George J. O'Hara, 8 x 10½ *in., 19 pp, paper bound. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.* $.75.

The problem here is to find the equations of response of three-dimensional linear elastic structures, having rotational and translational inertia to dynamic loading by foundation motions. Only the mathematical methods which are familiar to most engineering graduates are used.

The structure has multiple foundations which are independent of each

(Continued on page 441)

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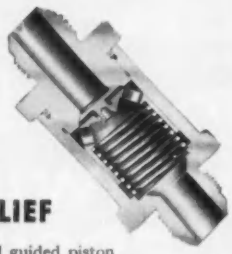

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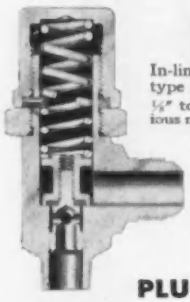

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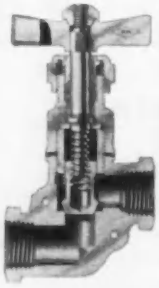

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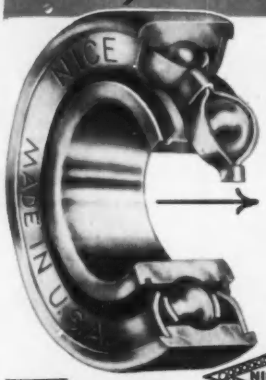

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other in their motions in all directions. Differential equations describing the response of the structure are seen to be similar to that of a simple oscillator subjected to similar foundation motions. Duhamel's integral is applied to determine the response to arbitrary motions in all directions of the multiple foundations.

The case of steady-state vibrations caused by continuous harmonic motions in arbitrary directions for all the foundations as well as one foundation is investigated, and the equations of response derived. The general equation for stress at any point is shown, and an example of its use is followed through.

Engineering Geometry and Graphics

HOLLIE W. SHUPE and PAUL E. MACHOVINA; *Ohio State University*, 6½ x 9½ *in.*, 347 *pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y.* $5.25.

The student who uses this text must have a familiarity with standard drafting procedure and instruments and know the basic principles of plane and solid geometry, algebra and logarithms. He will learn the problem-solving capabilities of graphical techniques, here called analytic graphics or engineering geometry.

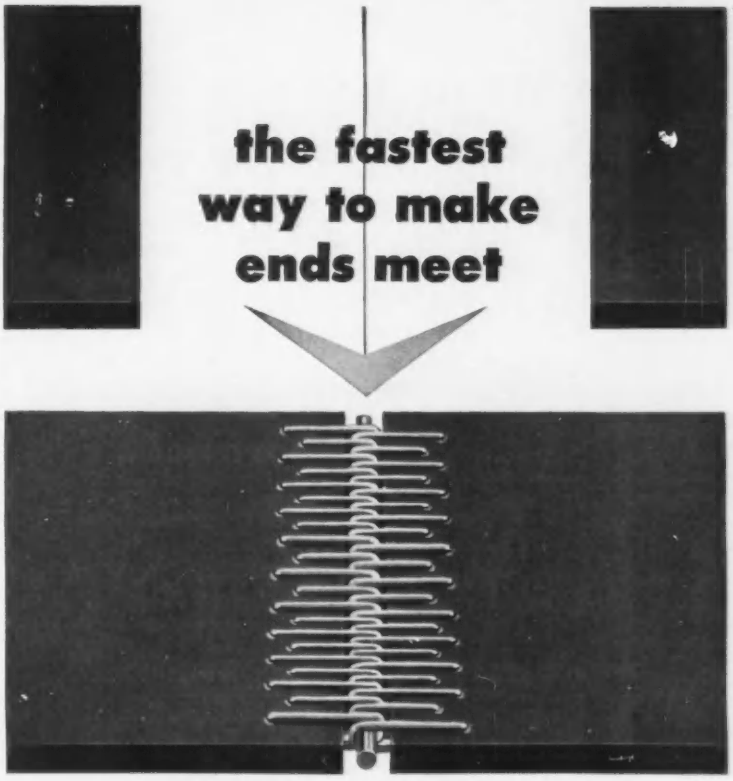
After a description of orthographic projection of objects, points and lines, the authors define and show their interrelationships with planes and curved surfaces. Additional chapters cover map projections, vectors, graphic scales, nomographs, and graphic integration and differentiation.

Standards on Copper and Copper Alloys

654 pp, 6 x 9 in., paper-bound. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., $5.75.

All of the ASTM standards pertaining to copper and copper alloys, which were developed by Committee B-5 on Copper and Copper Alloys, Cast and Wrought, (and related standard developed by Committee B-1 on Wires for Electrical Conductors and B-2 on

(Continued on page 469)



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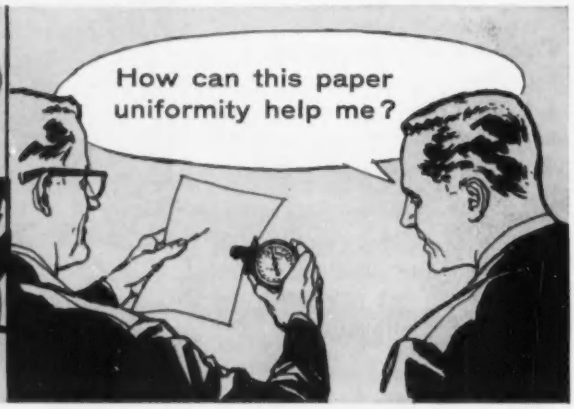

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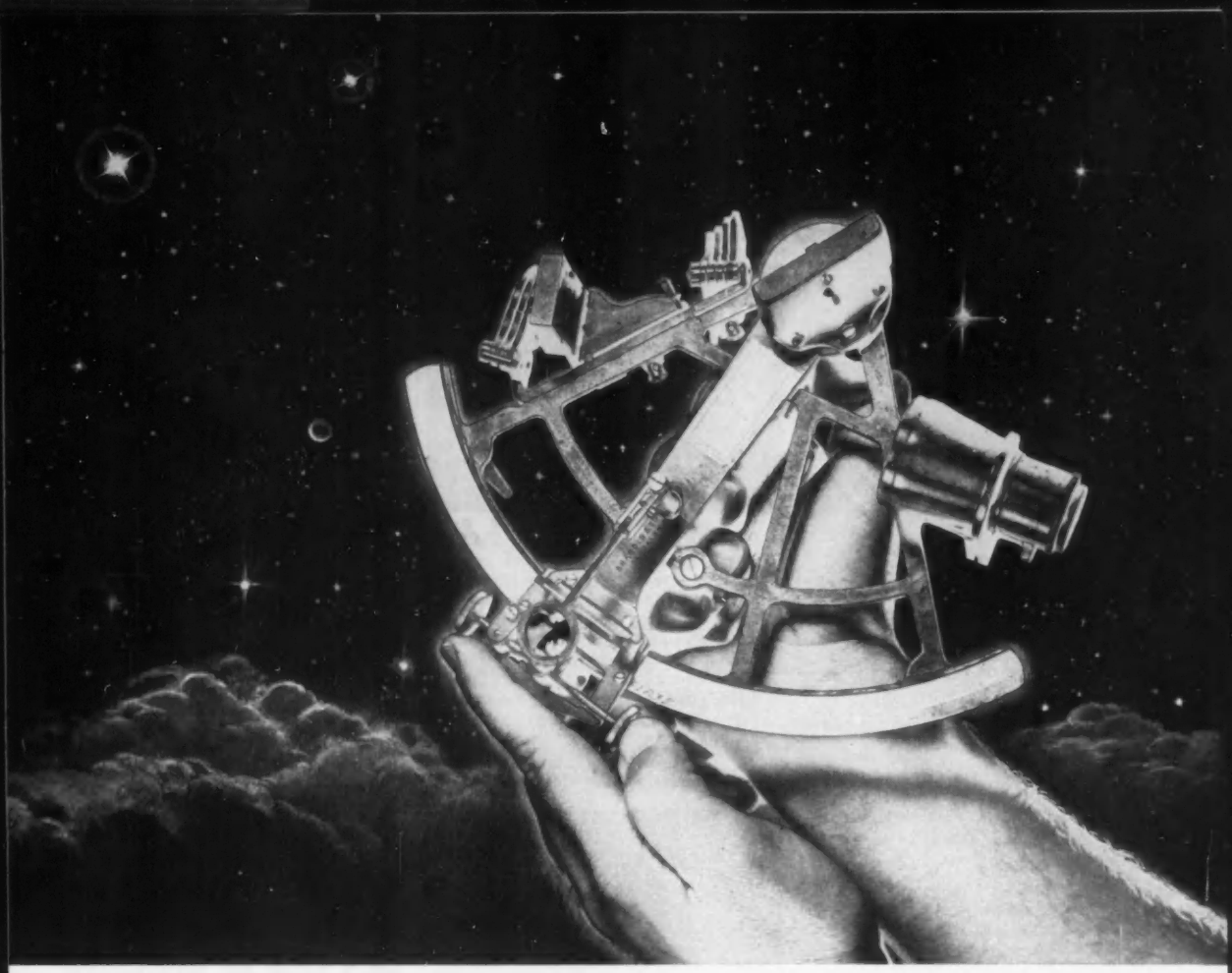

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ADVANTAGES OF FLEXIBLE SHAFTING

For Power Drive and Remote Control

by C. Hotchkiss, Jr.
Application Engineer,
Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative motion

2—eliminates exposed revolving parts

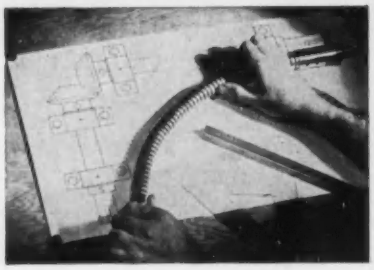
3—does not require accurate alignment

4—easy to install and maintain

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a 1¼ inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

Fig. 1



Relative Motion—Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾ inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Company.

Fig. 2

Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛ inch to 1¼ inches; for remote control applications in diameter sizes from ⅛ inch to 1⅜ inches. The 1¼ inch power drive shaft will transmit up to 10 HP while the 1⅜ inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering Bulletin 525.

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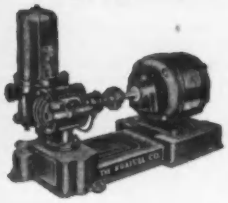

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289 Williams Ave., Hackensack, N. J.

Non-Ferrous Metals and Alloys) have been compiled in this book.

Standards cover copper, copper-alloy, and copper-covered-steel electrical conductors; copper and copper-alloy plate, sheet, strip, and rolled bar; copper and copper-alloy rod, bar, shapes and die forgings; copper and copper-alloy wire; copper and copper-alloy pipe and tube; copper-alloy ingot; copper-alloy castings; copper and copper alloy filler metals; and methods of test for copper and copper-alloys.

Of the material included in this compilation, 50 of the specifications have been revised. A new specification for threadless copper wire has been added since the previous edition.

American Standard Inspection of Fine-Pitch Gears

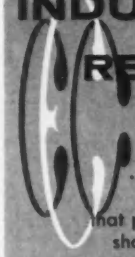
AGMA 236.04, ASA B6.11-1956, 8½ x 11 in., 41 pp. *Published by American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N. Y.* $2.50.

This standard for fine-pitch gears, which are defined as gears of 20 diametral pitch and finer, has been made flexible to meet the requirements of the greatly diverse applications of fine-pitch gears and to safeguard the interests of quality control in mass production. Fine-pitch gears lend themselves readily and economically to inspection methods in which measurements are made under conditions closely approaching those of their operation. The gear is rotated in intimate contact with a master, both mounted, on a variable center distance fixture. The displacements or variations in center distance are measured or charted by suitable means, giving a composite check as explained in this standard.

A choice of backlash to suit the particular application is provided by giving each class group several ranges of backlash. Two class groups were arbitrarily chosen: (1) commercial and (2) precision. Each group contains several classes, each based on the maximum permissible error, the allowable backlash value being given by a letter suffix and being applicable to any of the classes.

This standard does not cover tolerances on center distances and accuracy required in mountings.

INDUSTRIAL RETAINING RINGS



. . . the guaranteed retaining rings that provide inexpensive shoulders for positioning bearings and other product components on grooved shafts and housings.

. . . the guaranteed retaining rings that reduce production and assembly time, labor and costs; cut product weight and bulk.

SERIES 3000 Internal rings (NAS 50) applied axially into housings.

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*Series 1000 rings may be ordered stacked for easy one-at-a-time dispensing.

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Your products requiring flat-type mainsprings attain their maximum effectiveness when reserve power is always available and released evenly. Build-in a longer, smoother delivery of power with the famous Sandsteel Crosscurved mainsprings ...of highest quality Swedish steel... processed with a unique convex-concave construction that gives more energy per wind, a constant energy distribution. You add quality when you add Sandsteel Crosscurved mainsprings to your product!

Section showing crosscurved spring in housing

Use Sandsteel mainsprings for better engineering...greater efficiency...a superior product!

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Sandsteel Spring Division
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Here's truly compact design — production-engineered to give you top dependability at lowest possible prices.
Now — available for immediate delivery — From the small #1 Unit... 8 CFM at 1" static pressure, running at 20,000 RPM, to the #3 Unit... 150 CFM in free air running at 6000 RPM.
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Flexible Coupling

The most revolutionary design advancement for integral H.P. in a century!

Positive power transmission of rated load. Gear teeth on end castings match special rubber tube section.

- Load ranges—2½ H.P. to 25 H.P.
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- Prevents end thrust.
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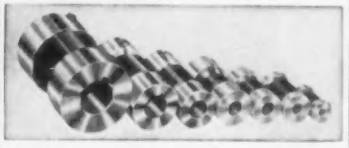
Dyna-Line . . .

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



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- True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.
- Lengths varied to design specifications in each series.
- Load ranges—1/15 to 1½ H.P.
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- Lowest O.D. for highest torque capacity.

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COUPLING DIVISION

DEPT. P-116, 1215 E. SECOND ST.
MICHIGAN CITY, INDIANA

OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Rod Into Bearing Balls

To the Editor:

According to an article in *Product Engineering*, Sept. 1956, page 212, entitled, "Bearing Balls are Rolled Instead of Pressed", you quote a recent report from the McGraw-Hill World News Bureau in Vienna, Austria, on the production of bearing balls.

We are very interested in obtaining a copy of this report and wonder if it is available.

—STANFORD R. OVSHINSKY
Detroit, Mich.

To the Editor:

We note in the Technical News section, in the Sept. issue of *Product Engineering*, a new method of making metal balls, by a ball rolling process, developed in the Soviet Union.

We would appreciate any further information you could supply on this process, or the sources where we would obtain such information.

—JOHN C. LOCKWOOD
Atlanta, Ga.

To the Editor:

I have read with interest an article entitled "Bearing Balls are Rolled Instead of Pressed" appearing in the Sept. 1956 issue of your magazine.

I would appreciate any further information that you can give me as to the source of this information. Your article states that the report came from the McGraw-Hill World News Bureau in Vienna, Austria, but it states that this method is being used in the Soviet Union. Any information as to how long this has been done in the Soviet Union or elsewhere would be g eatly appreciated.

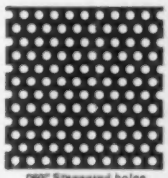
—JOHN W. MELVILLE
Cincinnati, Ohio

Ed.—This exclusive report has aroused considerable interest, as this sampling of the correspondence received indi-

(Continued on page 451)

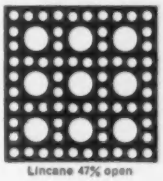
Perforated Materials for *Every* Application

Contact H & K for any perforated materials your product may require.



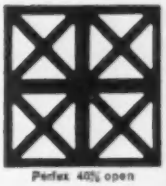
.060" Staggered holes. 126 holes per sq. in. 3/32" centers. 36% open.

We will be glad to work with you on your perforating problems.



Lincane 47% open

Perforating all metals, Masonite, plywood, paper, cloth and plastic.

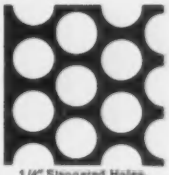


Perfex 40% open

Fill-in and mail coupon to office and warehouse nearest you.

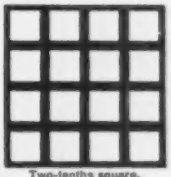
No. 00 Straight Holes 952 holes per sq. in. .020" diam. 30% open.

We have tools for perforating thousands of different patterns.



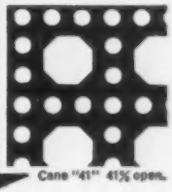
1/4" Staggered Holes. 5/16" centers. .25" diam. 58% open.

See our catalog in Sweet's Product Design File.



Two-tenths square, 64% open.

Round holes, square holes, slots, ornamental patterns, oblong holes, oval holes.



Cane "41" 41% open.

THE Harrington & King PERFORATING CO.

Chicago Office and Warehouse
5617 Fillmore Street
Chicago 44, Ill.

New York Office and Warehouse
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New York 6, N. Y.

Please send me—

- ☐ GENERAL CATALOG NO. 62
- ☐ STOCK LIST of Perforated Steel Sheets
- ☐ SAMPLES of Perforated Plastics and Paper
- ☐ PRICE INFORMATION (NOTE: Send specifications of perforated materials wanted. If necessary send drawings or sketches.)

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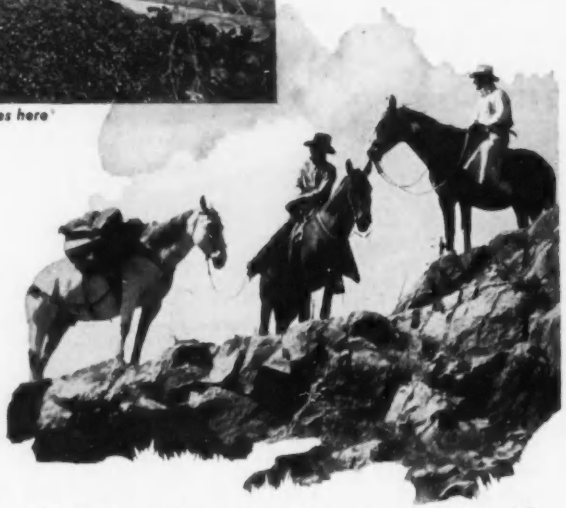
Look ten years ahead!

A Douglas engineer lives here

Will your income and location allow you to live in a home like this... spend your leisure time like this?



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Douglas has many things to offer the career-minded engineer!

...there's the stimulating daily contacts with men who have designed and built some of the world's finest aircraft and missiles!

...there's enough scope to the Douglas operation so a man can select the kind of work he likes best!

...there's security in the company's $2 Billion backlog of military and commercial contracts!

...and there's every prospect that in 10 years you'll be where you want to be professionally, and you'll be in both the income level and geographical location to enjoy life to its full.

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DOUGLAS **First in Aviation**

AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

What's so *different* about Ampco Metal?

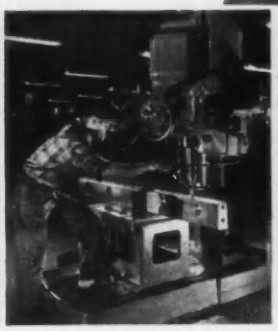
It's made to last — and does!

Not by chance, either! Ampco's pioneering experience in the development and production of special copper-base alloys has resulted in strict manufacturing precautions. These and the narrow metallurgical limits, the continual controls, the best in equipment and experienced personnel are all part of the Ampco secret. Yes, they're the big reasons why Ampco alloys enjoy world-wide acceptance — why so many manufacturers insist on the year-to-year uniformity and reliability that results from Ampco's "know-how" and controlled alloy-making procedures.

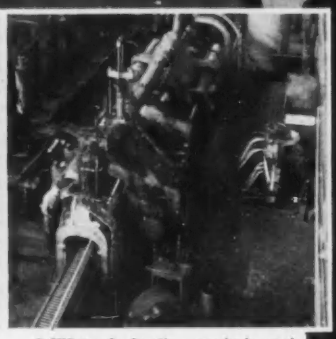
And because Ampco is made to last — and does — it performs its greatest service in those applications where severe load, wear, or corrosion problems must be solved.

Here's another thing that's different about Ampco Metal: It is produced by centrifugal-, sand-, or precision-casting, shell-molding, extrusion, and forging processes — on a production basis. It's also available as sheet or plate. Your Ampco field engineer can make unbiased recommendations, because Ampco offers this complete one-source service. Call him in. Also write for Bulletin 33.

Sand castings in any size up to 14,000 pounds — and centrifugal castings up to five tons — are produced in Ampco foundries.



Ampco's one-source service includes production-run machining of copper-base alloys to the quality standards of the aircraft industry.



2,275-ton hydraulic press in Ampco's modern, laboratory-controlled mill for extruding rods, bars, hollow rounds, and shapes.

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AMPCO® **THE METAL WITHOUT AN EQUAL**

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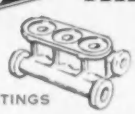

SAND CASTINGS

CENTRIFUGAL CASTINGS

FABRICATION

FORGINGS

SHELL-MOLDED CASTINGS

EXTRUSIONS

SHEET AND PLATE

MACHINED PARTS

D-56

PRODUCT DESIGN WITH DUREZ PHENOLICS

WESTINGHOUSE

makes sure **8** *ways...*

with Laundromat parts of* **DUREZ** *phenolics*

Probably no single group of plastics offers design engineers such wide latitude in meeting specific service conditions as the Durez phenolics. These eight components now helping to implement the slogan "You can be sure if it's Westinghouse" are a notable example.

The problem was to create long-wearing, non-corrosive, economical parts of light weight for new Laundromats. All these objectives were achieved by replacing metal with parts molded of *four different* Durez materials. Working as a team, Westinghouse engineers and the molder, GENERAL INDUSTRIES CO., selected each of the four Durez phenolics for better performance at lower manufacturing cost on the job it must do.

To save time in capitalizing on the versatility of Durez, talk over your design problems first with your molder. Or call on our Technical Field Service in putting its mechanical, electrical, and chemical properties to profitable use.

DUREZ®

Phenolic Plastics that fit the job

DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
1011 Walck Road, North Tonawanda, N. Y.

HOOKER CHEMICALS PLASTICS

**Laundromat ® by Westinghouse Electric Corp.*

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cates. This method has been worked out by the Central Construction Bureau of the Metallurgical Machine Building Institute. Chief of the development is A. I. Zerikov, Corresponding Member, Academy of Sciences, USSR. The method, usable for balls up to 80 mm (3.148 in.) dia, has been described by W. P. Anissiforov and S. P. Granovski, both candidates of the Technical Sciences, in the Soviet monthly *Science and Life*.

Printed Wiring

To the Editor:

I would like to compliment you on the article, "Printed Wiring for Industrial Service", appearing in your Aug. 1956 issue.

Please advise if reprints will be made available shortly and also prices for various quantities. —J. A. GENTILE
Massachusetts Institute of Technology

Ed.—Reprints of this article are available at $0.25 per single copy and $0.23 per copy in lots of 100 or more.

On the Human Side

To the Editor:

The contemplated "humanistic" articles mentioned in your editorial in the September issue sounds good.

Some time ago, the following appeared in some magazine—

"Historians often write as though the story of mankind were made up of wars, kings, architectural styles, philosophical trends and the like. Great as these factors are in molding the lives of men, it is actually the tools and machines men invent which shape their daily lives into the routine of barbarism, of feudalism, or of modern industrial democracy. For it is only with tools and machines that human labor can be transformed into the things—from pins to cities—that give civilization its form."

I can't recall the name of the magazine but it seemed fitting to pass along these words at this time.

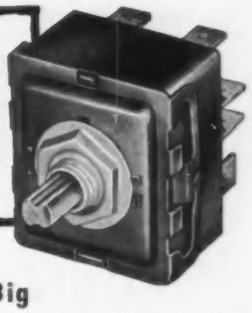
—GEORGE E. ROWBOTHAM
Hartford, Conn.

Ed—Thank you for the quote, with which we agree 100 per cent. And we

(Continued on page 455)

This Little Switch Goes to Market

. . . in air conditioners, fans, unit heaters, appliances, motor and resistive circuits.



This Little Switch Is Big

Ratings range up to 25 A. at 120 or 240 V., and ½, ¾ and 1 hp at 120 V. and 2 hp at 240 V., A.C. U.L. Approved. (Small D.C. ratings also available.) *But base is only* 1½" x 1¼" x ⅛".

This Little Switch Saves Money

Costs less—permits simplification of your designs. Spindle extensible through base to permit ganging of mechanical and electrical controls . . . spade terminals for quick wiring . . . dummy terminals, if required, to eliminate need for blocks.

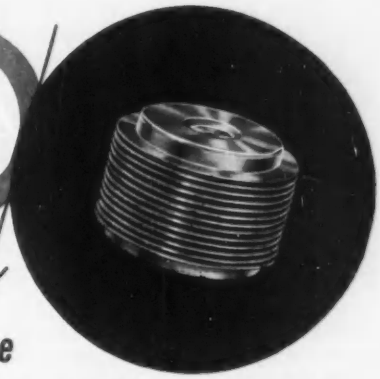
This Little Switch Is The NEW "Diamond H" Series 390 Rotary

. . . single or double pole, two to twelve positions with stop as required. Single, two-hole or special mounting arrangements. Completely interchangeable with the widely used "Diamond H" Series 240 switches which are still available.

Write today for complete information to meet your requirements

THE HART MANUFACTURING COMPANY
206 BARTHOLOMEW AVE., HARTFORD, CONN.

REJECTS VIRTUALLY ELIMINATED



. . . . with Miller Phosphor Bronze

A manufacturer of electrical controls was plagued by two problems in the production of this refrigeration control bellows component: Rejects were excessively high—as much as 45%—and chemical action of the refrigerant created a corrosive film which impaired accuracy. The company's own metallurgists specified a phosphor bronze alloy to meet these problems. But only Miller had the special skills to actually produce this tailor-made metal. Now, phosphor bronze by Miller has reduced rejects to the absolute manufacturing minimum—and effectively resists chemical action. Miller *specializes* in tailor-made phosphor bronze alloys . . . to solve your toughest production problems. At Miller, Phosphor Bronze is the *main* line not a side line.

miller SINCE 1844

THE MILLER COMPANY • MERIDEN, CONN.
ROLLING MILL DIVISION
America's Quality Phosphor Bronze

HOWELL MOTOR BRIEFS

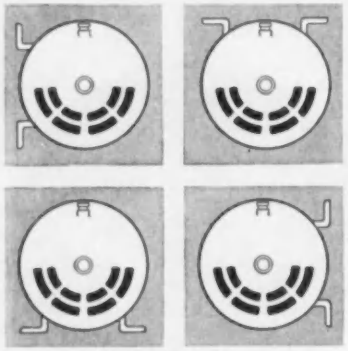
Quick facts for those who apply and specify electric motors

Flexibility of Design Aids Motor Applications

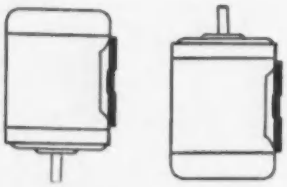
When they originally embarked upon the program of developing the basic Series 100 motor design for the new rerated frame sizes, Howell engineers set goals considerably above and beyond the requirements of the NEMA specifications. Among them, "maximum flexibility" of design was achieved to a degree that is outstanding in the motor industry . . . and that directly benefits machine designers who utilize standard motors.

Involved is not only unusual flexibility of positioning and lead connections, but a ready interchangeability of the five basic enclosure types within each frame size.

DESIGNED FOR MOUNTING IN ANY OF SIX POSITIONS

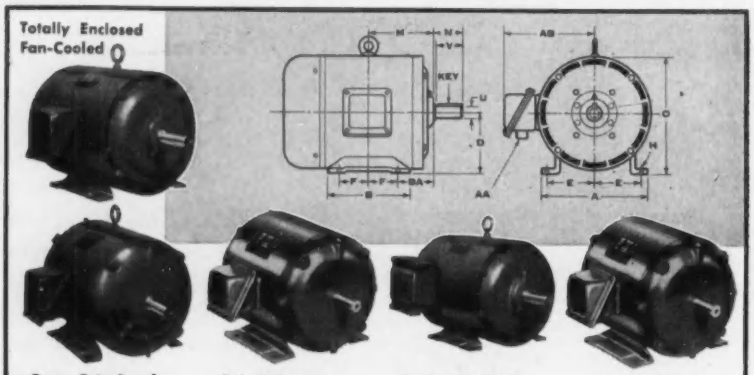


As illustrated by the diagrams above, Howell Series 100 Open Drip-Proof motors can be side-wall or ceiling mounted simply by revolving the end plates. The other four basic enclosure types do not even require this simple change.

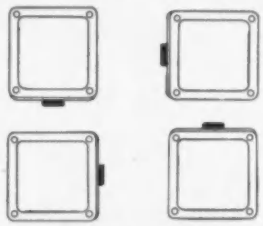


SHAFT DOWN SHAFT UP

Series 100 Totally Enclosed Fan-Cooled motors – in fact all of the five enclosure types – can also be mounted shaft down or shaft up with no modification in design required.

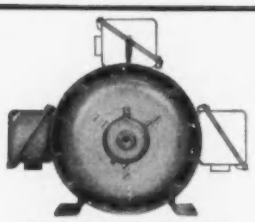


FIVE BASIC SERIES 100 ENCLOSURES HAVE SAME DIAMETERS, SHAFT AND MOUNTING DIMENSIONS — Unlike many other motors, the basic Howell Series 100 enclosures do not vary in diameter (or any of the essential mounting dimensions, except length) from one type to another (except a few 2-pole ratings). This is because of the way Howell accomplishes motor cooling, with "heat source" ventilation ducts in the stator itself . . . not by enlarging Totally Enclosed Fan-Cooled or Explosion-Proof frame diameters. This uniformity simplifies space allocations for the machine designer and allows for interchangeability of enclosure types to meet varying job requirements.



BOX EASILY ROTATED FOR 4-WAY HUB LOCATION

Series 100 conduit boxes are mounted to the frames with 4 screws, accessible for easy rotation of the box so that the integral, threaded nipple takes conduit from any of four directions.



CONDUIT BOX LOCATES TO FIT ANY REQUIREMENTS

For further flexibility, a simple modification can be specified for positioning of the conduit box in any of three positions around Series 100 frames.

GET COMPLETE DETAILS WRITE FOR BULLETIN H-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

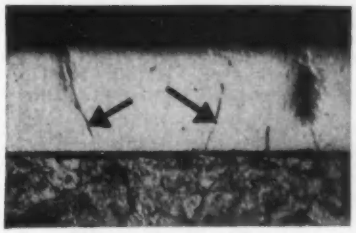
Plastisol coatings give protection "in depth"

Unique chromium plate gives solid corrosion protection

Deposits of Unichrome Crack-Free Chromium offer important advantages over ordinary chromium plate. They remain free from the cracks through which corrosives can penetrate ordinary chromium plate and attack the basis metal. (See photo below).

Crack-Free Chromium Plate therefore needs no nickel undercoat to stop corrosion. It offers a number of other features of interest to designers. These include:

Improved non-galling, non-seizing properties; superior resistance to thermal shock and impact. And, of course, wear resistance, hardness and low coefficient of friction. Send for Bulletin CFC-2.

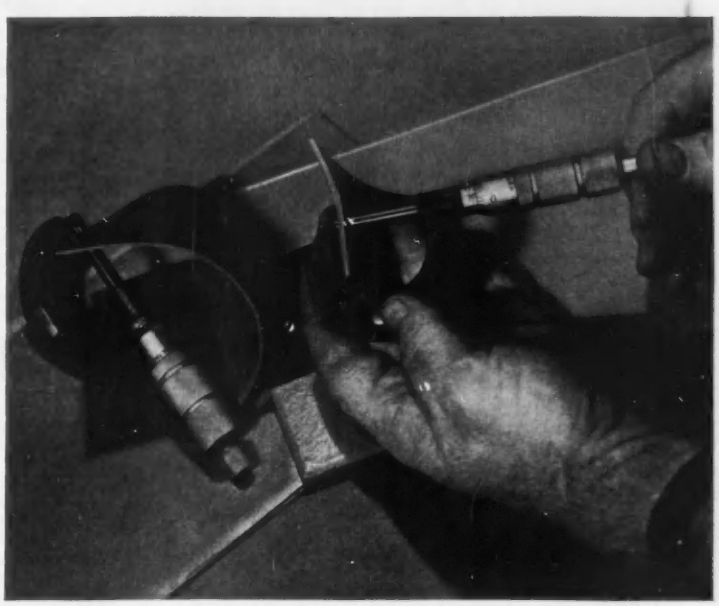


Cross section of etched ordinary chromium 0.00125" thick, unretouched. Note that some cracking extends to steel, opening the way for rusting. These flaws are absent in Unichrome Crack-Free Chromium.

Unichrome is a trademark of Metal & Thermit Corp.

METAL & THERMIT
CORPORATION

General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Toronto 1, Ont.



Unichrome Plastisols provide single coat thicknesses approaching those of sheet materials. Thinner coats can also be applied as desired.

Vinyl plastisols form films with excellent resistance to chemical attack. But it's the *thickness* of resilient film buildup that really sets a plastisol coating apart from the usual coating . . . and makes ordinary metals coated with plastisols fit for heavy duty.

APPLICATION MADE EASY

Thickness of 60 mils or more per coat can be sprayed with Unichrome "Super 5300" Coating. Products dipped into Unichrome Series 4000 Coating can have a film thickness up to $\frac{3}{16}$ inch. Such body means *pore-free* protection, ample section to absorb damaging impact, and a *long-wearing* abrasion-resistant finish.

Many plants specializing in applying plastisols have enlarged facilities to handle bigger and bigger parts and products. Spraying or dipping is practical on *any* size product for which there are facilities to heat and hold the coated object at 350° to 365°F for curing.

OTHER ADVANTAGES OFFERED

Plastisol coated products also get *seamless* protection against acids, alkalies, moisture, and other corrosives. The finish has satiny gloss, resists abrasion, deadens sound, insulates electrically, doesn't age and crack.

Record service has been delivered by Unichrome Plastisols on such diverse applications as pump impellers, dishwashing racks, agitators, ductwork, screens, cart bumpers, tool and work holders, plating racks, thumbtacks, enclosed tanks . . . to cite a few. Obviously, Unichrome Plastisols are versatile. Send for Bulletin VP-2 for more ideas.

Presenting another NEW WISCONSIN HEAVY-DUTY Air-Cooled ENGINE

The FULL-POWERED V-Type 4-Cylinder 30 hp. Model VH4

This rugged new engine has been added to the Wisconsin line to fill the horsepower gap between the Model VF4 25 hp. and the Model VG4D 36 hp. Wisconsin Engines. At the same time, the mounting base is dimensionally identical to the Models VE4 and VF4 to permit convenient replacement of the latter engines if greater power is required.

The Model VH4, which now makes its bow for the first time, is the most powerful engine of its type and size available today, in our estimation. It is an engine of basic High Torque design which gives it the important advantage of being able to deliver maximum usable *Lugging Power* that carries the load through the hard, heavy pulls. It has been designed to give you the best possible performance at all engine speeds from 1400 to 2800 rpm., even when operating under intermittent shock-loads or under constant load, continuous service.

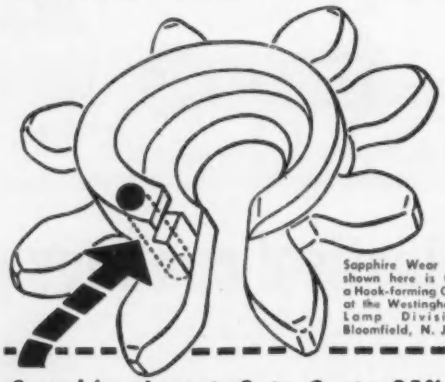
The Model VH4 is a heavy-duty engine in all respects, built for hard service under all operating conditions, at temperatures from sub-zero to 140° F. (60° C.). It is an exceptionally smooth-running, even-firing engine and has all the traditional heavy-duty features that characterize *all* Wisconsin Models, from 3 to 36 hp. It can be supplied as an "open engine" with side-mount fuel tank, or as housed power unit and may be equipped with electric generator and starter (or starter only), clutch, reduction or clutch-reduction assemblies . . . and is adaptable to operation on a variety of fuels such as gasoline, kerosene, natural gas, Butane, Propane or fuel oil of 35 Octane rating or better.

Learn more about this new engine. Write for Bulletin S-196 for detailed data and engineering specifications.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN



Sapphire Wear Part shown here is from a Hook-forming Gear at the Westinghouse Lamp Division, Bloomfield, N. J.

Sapphire Insert Cuts Costs 85%

for Westinghouse Lamp Division—and they write us:

"The use of the sapphire at the critical wear point has drastically reduced the wear problem, for the Forming Gears with inserts outlast the gears without inserts at an average ratio of 10:1. Using a sapphire insert in the gear has meant an 85% reduction in the yearly cost of this item in addition to reducing expensive machine downtime."

If you have a friction or wear problem that means frequent replacement of close-tolerance, expensive parts such as this, send for an analysis by our engineering staff — no charge, of course. Other typical solutions are illustrated in our brochure — send for it today!

aurele m. gatti inc. "Precision Sapphire Products Miniature Sub-Assemblies"

Main Office and Factories — 522 Tindall Ave., Trenton, N. J.
Manufacturing Subsidiary — Guayama, Puerto Rico

A TECHNICAL NEWSLETTER ON LUBRICATION WITH MOLYKOTE . . .

IF YOU HAVEN'T RECEIVED YOUR COPY SEND FOR IT RIGHT AWAY!

Every issue features a technical article on the use of MOLYKOTE Lubricants in industry ● "How-to" stories on tough lubrication applications ● Filled with engineering data which applies to all industries ● Being published regularly.

THE ALPHA MOLYKOTE CORP.

Main Factories: 65 Harvard Avenue, Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

...the *only* Coupling with truly Spherical Teeth

This exclusive coupling is widely endorsed for use on Tandem cold mills, Hot mills, Roller levellers, Pinch rolls, Slitters, etc.—wherever counter-rotating rolls are found—where compensation for angular and parallel displacement is required to facilitate roll changing—and to compensate for variable roll centers due to work roll grinding and/or due to thickness of material requirements. Sphereflex Roll Shaft Couplings give ±7% angular capacity, with a very minimum of backlash.

Sphereflex is the *only* coupling with truly *spherical teeth:* Root diameter, pitch diameter and outside diameter are generated as segments of concentric circles, giving a ball and socket action, and assuring highest torque-carrying capacity . . . all mating teeth maintain an area contact under load at the center of the male cut teeth, thereby *preventing rolling point contact* at maximum misalignment.

All exclusive points of design and construction of this unusual coupling are illustrated and explained in Bulletin C-561 . . . Send for copy on your Business Letterhead.

See the newest developments in Mechanical Power Transmission at our Booth #80—22nd National Power Show, New Coliseum, New York City, November 26-30.

phillie gear®

PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS

Virginia Gear & Machine Corp. • Lynchburg, Va.

will extend our equally sincere thanks when you send us criticisms of our new section, entitled "Interesting to Note . . .", in this issue. Perhaps some reader knows the author of your quote.

WR² and Its Continuing Significance

To the Editor:

We have been asked for a copy of the article entitled, "Significance of WR² and How To Calculate It", which was written by John W. Harper of General Electric in October 1934. This appeared in *Product Engineering.*

If it would be possible, I would appreciate a tear sheet of this article.

—W. F. Stolberg
General Electric Co.

Ed.—Tear sheets of the original article were exhausted years ago. However, we have had such a continuing deluge of requests for it over the years that three years ago we had Harper bring the article up to date. It was published for the second time in our 1954 Annual Handbook of Product Design.

Manganese Copper

To the Editor:

We are interested in the article on "Manganese Copper", which appeared in *Product Engineering* for May 1956.

We would appreciate it if you could provide the names of manufacturers presently producing this material in both wrought and cast forms.

—W. E. Hintz
Cudahy, Wis.

Ed.—Here are the names of two manufacturers who have indicated their intention to produce manganese-copper alloys: Ampco Metal, Inc., 38 and Maple St., Milwaukee 46, Wis.; Simonds Saw & Steel, Lockport, N. Y. We have also been advised that the Foote Mineral Co., Berwyn, Pa., is planning to investigate the alloys from the standpoint of production.

Also, the Bureau of Mines (with whom the authors of the article in our May issues are associated) are willing to send samples and information to companies who wish to make experimental applications or tests of the damping and other properties. In

(Continued on page 459)

it's that simple!

Draftsmen want to use STANPAT in place of the old-fashioned time-consuming method of re-drawing and re-lettering specification and revision boxes, standard symbols, sub-assemblies, components, and cross sections.

STANPAT reprints your standard drawing details on acetate sheets with adhesive on front or back. Guaranteed not to dry out, come off, or wrinkle. Reproductions come crisp and clear. Save drafting time and money; use STANPAT whenever drawing details re-appear on your tracings.

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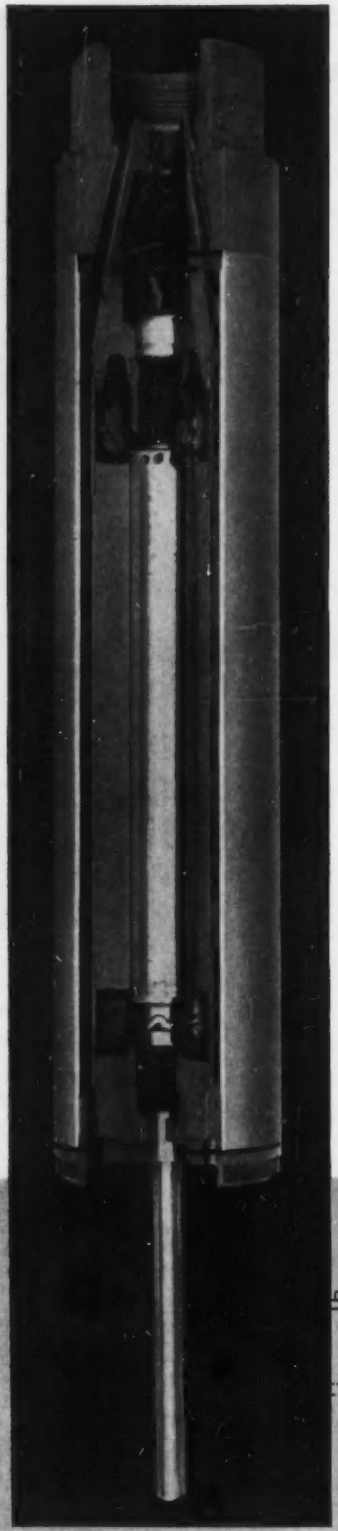


7 "bonus values" of Leland's submersible motor!

Now both motor and pump can be installed right in your gasoline storage tank! Even with high octane gasolines, the new Leland explosion-proof motor eliminates vapor-lock . . . uses the gasoline itself for lubrication and cooling. This completely new ¾ hp, 230v AC thermally protected motor measures only 3½ inches in diameter . . . fits into existing tanks. It's fully U.L. Approved for Class I, Group D service.

Simple and rugged, built for long-life economy, this new Leland submersible pump motor has these 7 big advantages over other motors:

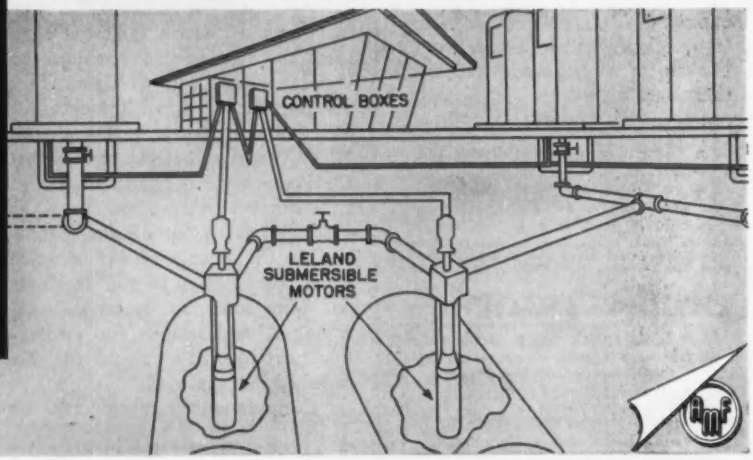
1. Completely self-contained unit includes outer shell necessary for gasoline passage – makes expensive extras unnecessary.
2. Extruded aluminum outer shell becomes main structural member – ribbed design provides much needed rigidity.
3. 9/16" chrome-steel shaft extension provides greater strength–prevents mechanical distortion.
4. Increased annular area allows 10% greater gasoline flow – minimizes trouble-making back pressure and turbulence.
5. Suction stub mounts without adaptor castings – reduces expense required with other motors.
6. Plastic-impregnated windings surpass wet-design insulation requirements – remain trouble-free for extra-long service life.
7. Leland's integrated motor design permits complete removal of pump or stub *without* disassembling motor.

In addition . . . a remote-control box is supplied with each Leland submersible pump motor. Includes thermal overload protector, line control and starting relays, starting and running capacitors.

30 years ago Leland developed the first gasoline curb pump motor to receive U.L. Approval – today, Leland gasoline pump motors outsell all others combined. So there's good reason why, for explosion-proof motors of any kind, your best bet is Leland. If you would like more information, and/or a copy of a new brochure on the submersible motor, write, wire or phone us –TODAY!

Another AMF Product
LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY



New Grant 3400 thinslide

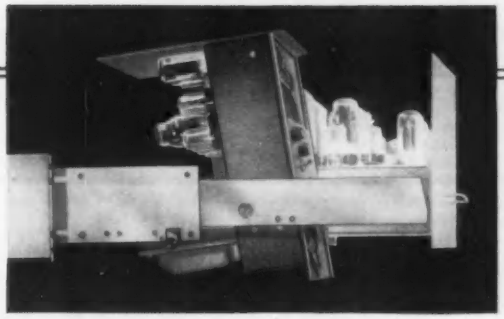
mounts standard 17" chassis in standard 18" rack or cabinets

REQUIRES ONLY 19/64" SPACE PER SIDE—

YET HAS

FULL ROLLER ACTION

(fits RETMA *rack hole spacing)*



The Grant 3400 Thinslide requires only 19/64" space per side—installs readily in standard racks and cabinets. Allows instant access to chassis measuring from 10" to 16" deep. Tilts through 100° for under-chassis servicing. Positive lock in "out" position. Lock has finger-tip release for instant return or removal of chassis. Eight hardened steel rollers carry the rated load of 100 lbs. smoothly and easily—durability insures frictionless rolling for thousands of cycles of use.

Slide mounting not only provides for quick access—it usually eliminates need for rear access doors and rear aisles—a very important saving of space.

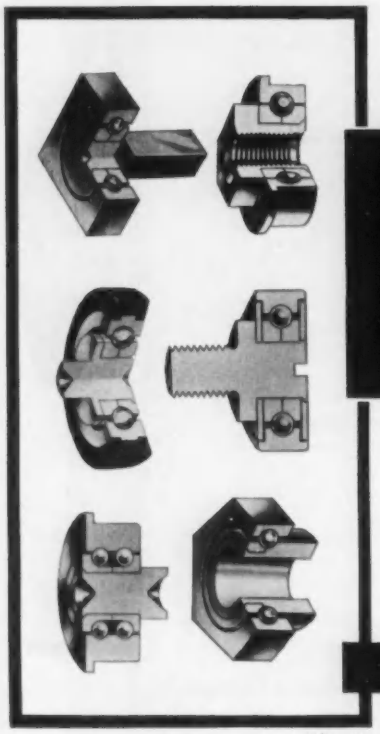
The Grant 3400 is a versatile slide, suited for use in your *product*, in *plant equipment, prototype* and *breadboard* work, and in *production line or field test equipment.* Very moderate cost allows a wide range of applications in original equipment.

Write today for Grant 3400 Thinslide Technical Bulletin—contains full data and specifications.

Grant INDUSTRIAL SLIDES

Grant Pulley and Hardware Corporation

factories: **31-77 Whitestone Parkway, Flushing 54, N. Y.**
944 Long Beach Avenue, Los Angeles 21, Calif.



UNGROUND BALL BEARINGS

For All Industries

KILIAN

Long life and service are assured you because —

1. All component parts are machined from steel bars.
2. Each component part is properly heat treated.
3. Every Kilian Bearing is designed for a specific application.

Neoprene and Nylon tired outer races are available where quiet operation is desired.

Distributors in All Principal Cities ***Catalog on Request***

KILIAN MANUFACTURING CORP.

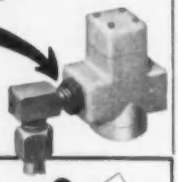
SYRACUSE, NEW YORK, U. S. A.

ASSOCIATED COMPANIES:
Kilian Manufacturing Corp. (Canada), Ltd. 240 Fleet St. East, Toronto 2B, Ont.
Fischer Bearings (Canada), Ltd. 240 Fleet St. East, Toronto 2B, Ont.
Kilian Steel Ball Corporation 100 Wellington St., Hartford, Conn.

TRU-O-SEAL TEFLON SEAL

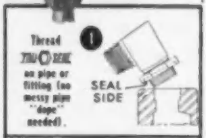
PAT. PENDING

STOPS PIPE THREAD LEAKS instantly!



Prevents future leaks!

TRU-O-SEAL does away with messy pipe "dope" compounds, eliminates damage caused by overtightening of conventional leaky joints, and is immune to ALL known hydraulic fluids and to steam, air, water, solvents, and practically all gases and chemicals. It withstands temperatures from —100° F. to plus 500° F., saves cost and labor of special or welded fittings, and has been fully field tested and proven by leading manufacturers. Comes in ⅛" to 2½" pipe thread sizes.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Write for data and prices

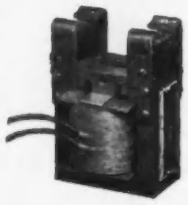
TRU-O-SEAL DIVISION Flick-Reedy Corporation

2002-04 N. Hawthorne Melrose Park, Ill.

"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.

SOLENOIDS

G-211 solenoid, 10 lbs. at 85% voltage, 1½" stroke.



NA-726 solenoid; 16 lbs. at 1" stroke, 100% voltage.

G-200 line of solenoids. Replacement for all sizes of General Electric Co.'s CR-9503-200 line of solenoids.

NA-700 line of solenoids, replacement for National Acme solenoids, size for size, for all modifications.

The solenoids of both the above replacement lines are all thoroughbred Trombetta solenoids. All dimensions of interest to the user are the same as the respective solenoids they replace. The pull and pull characteristics are identical. In either case, we are in a position to furnish replacement units for any and all modifications. They are available for all voltages and frequencies, including direct current.

See our catalogs in Sweet's Catalog Service. Ask for more information.

TROMBETTA SOLENOID CORP.

329 N. MILWAUKEE STREET • MILWAUKEE 2, WISCONSIN

the event that you may want to request such assistance, we are listing their complete address below: Mr. R. G. Knickerbocker, Chief, Div. of Mineral Technology, Region IV, U. S. Dept. of the Interior, Bureau of Mines, P. O. Box 136, Rolla, Mo.

Thickness Gages

To the Editor:

In Section A of your 1956 Product Design Handbook issue there is an article entitled, "Radioisotopes in Research and Industry". In reading this article, the thought occurred to me that perhaps we might have an application for beta-ray thickness gages.

It will be greatly appreciated if you could help put me in contact with someone who has had experience in this field, preferably someone who can supply necessary equipment.

I would also like to comment at this time on the fact that I have been reading *Product Engineering* for a number of years. I would like to commend your organization for publishing a technical periodical which never fails to provide articles and items of special interest.

—Gerhardt H. Piel
Owens-Illinois

Ed.—In response to your request, we are listing below three companies who make radioisotope gages. General Electric Co., X-ray Dept., 4855 Electric Ave., Milwaukee 1, Wis.; Tracer Lab., Inc., 130 High St., Boston, Mass.; Industrial Nucleonics, 1208 Chesapeake Ave., Columbus, O.

We would also like to thank you for your kind comments about *Product Engineering*.

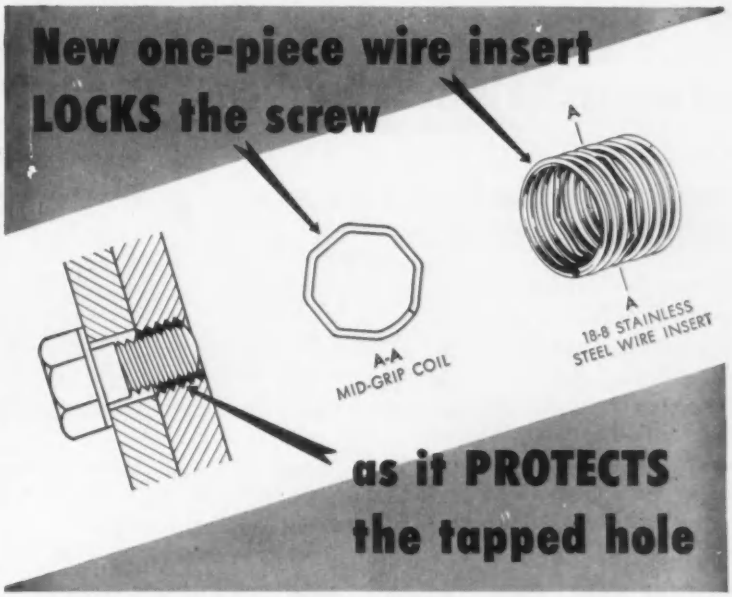
Indexing Technique

To the Editor:

For some time now, I have been indexing feature articles in *Product Engineering* on the binding edge, where you carry your volume number. Because I file the current year's magazines in a file drawer, the edgewise index is helpful in quickly finding an article.

—M. O. Young
Wilmington, Del.

Ed—We do not use this method because we bind our index between hard board covers. However, other readers may well profit from your method of indexing.



Withstands vibration, heat, corrosion — Meets AN-N-5b lock nut specifications

Here is a ONE-PIECE stainless steel thread insert that will *lock the screw against loosening* as it permanently protects the tapped hole. The secret is in the Mid-Grip coil. Shaped like a polygon, its chords exert a spring pressure on the screw thread and prevent rotation at less-than-rated torque. No loss of torque occurs at elevated temperatures or after repeated disassemblies.

NO EXTRAS—The *Heli-Coil** Screw-Lock (Mid-Grip) Insert employs no locking rings, pins, plugs, tabs or wiring. It can be installed from the front or top. Think of the money — and assembly time — you can save!

NO PROJECTIONS — Screw-Lock Inserts furnish AN-N-5b lock nut torque *right down inside the parent piece* . . . eliminate costly weight and space . . . improve design.

NO WEAR, NO CORROSION— Like regular *Heli-Coil* Inserts, new Screw-Lock Inserts are made from 18-8 stainless steel wire, and normally outlast the unit they protect. They permit smaller, fewer fastenings, and require minimum surrounding material. Screw-Lock Inserts are available in popular NC and NF sizes with choice of two lengths.

Mail coupon for complete data—or better still, see Yellow Pages of your phone directory — "Inserts — Screw Thread" for name of your local Heli-Coil Applications Engineer. Call him now!

Regular *Heli-Coil* Inserts (no locking action) put corrosion-proof, strip-proof stainless steel threads in soft materials . . . permit smaller, fewer fastenings, lighter weight, reduced cost.

HELI-COIL **SCREW-LOCK INSERTS**
Products of Heli-Coil Corporation, Danbury, Conn.

*Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
171 Shelter Rock Lane, Danbury, Conn.

☐ Send complete design data on *Heli-Coil* Screw-Lock Inserts.
☐ Send design manual on standard *Heli-Coil* Screw Thread Inserts.
☐ Put me on a list to receive "*Heli-Coil*," case history periodical.

Name_____ Title_____
Company_____
Address_____
City_____ Zone_____ State_____ 3534

IN CANADA: W. P. Watkins Co., Ltd., 41 Kipling Ave. S., Toronto 18, Ont.

ENGINEERS FOR IMMEDIATE PLACEMENT

- Electrical engineers
- Mechanical engineers
- Electronic engineers
- Computer engineers
- Solid-state physicists

ENGINEERING AT NCR MEANS:

IMMEDIATE, PERMANENT POSITIONS in Mechanical Engineering, Electrical Engineering and Physics Research Division.

ENGINEERING PROJECT WORK in Adding Machines, Cash Registers, Accounting Machines, Computers and related Data Processing Equipment in Dayton, Los Angeles and Ithaca, New York.

OPPORTUNITIES IN DESIGN, development, production-engineering and packaging of mechanical, electronic and electro-mechanical devices.

SOME EXPERIENCE IN DEVELOPMENT, design and application of high-speed, light-weight mechanisms of the intermittent-motion type—or experience in digital devices and components is desirable, but not essential.

AMPLE TRAINING and orientation is available to all employees.

ENGINEERS

AS AN NCR ENGINEER, YOU WITH YOUR FAMILY, WILL ENJOY:

UNLIMITED OPPORTUNITY in the broad, ever-expanding field of Business Machine Engineering and Research.

AN EXCELLENT SALARY, plus exceptional benefits of lifetime value for you and your family.

A RECREATIONAL PROGRAM for year-round enjoyment for the entire family, including a new NCR Country Club with 36 holes of golf, and a 166-acre employees' park for outings with swimming, boating and supervised play for children.

LIVING IN DAYTON—an attractive, progressive city with outstanding school facilities.

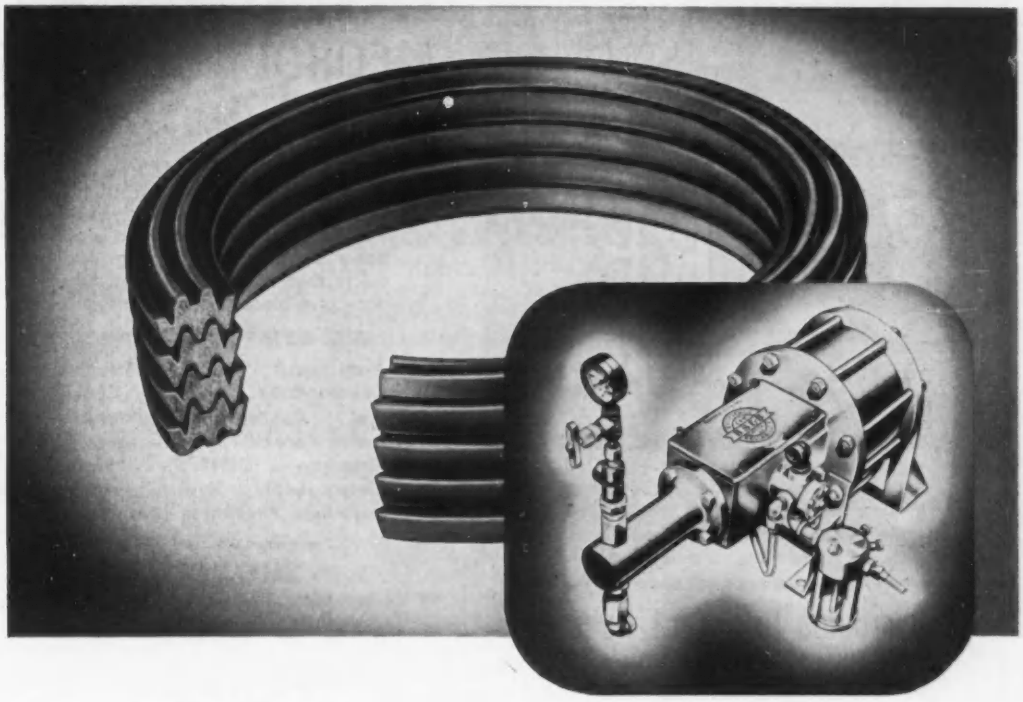
YOUR WORK AT NCR with its friendly, family atmosphere, where you work with people who, like yourself, have decided to build their professional future with NCR.

ACT AT ONCE

- Send resume of
- your education, experience
- and geographic preference to:
- Employment Department,
- Professional Personnel Section 7

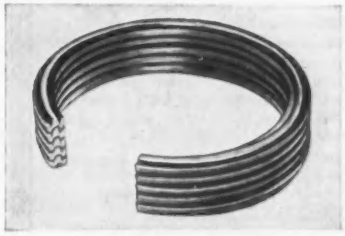
THE NATIONAL CASH REGISTER COMPANY • DAYTON 9 • OHIO

J-M Uneepac® does it again!



"Very satisfactory sealing service against wide variety of fluids and pressures up to 5,500 psi"

says Black, Sivalls and Bryson, Inc. makers of BS&B Glycol Pump



Uneepac comes in two types. Shown here is design for flange widths up to ½" which is used in BS&B Glycol Pump. Large illustration above shows design for flange widths over ½".

Chalk up another success story for Uneepac—Johns-Manville's automatic ring packing. In the BS&B Glycol Pump, fluids handled include triethylene glycol, diethylene glycol, gasoline, and various types of oils, alcohols and petroleum treating chemicals. Working pressures range from 125 psi to 5,500 psi with average operating pressures at 3,000 psi. Yet despite these rugged service conditions, Uneepac has delivered—in Black, Sivalls and Bryson's own words—"very satisfactory service."

Many other packing users have acclaimed J-M Uneepac for its long, trouble-free service. Each ring is a complete packing unit. Fewer rings are needed than ordinarily required and stuffing box size can be reduced to the minimum. Each ring centers itself automatically on the preceding ring to simplify installation. This exclusive design also permits fluid pressure to act upon each lip individually and protects lips from excessive gland pressure.

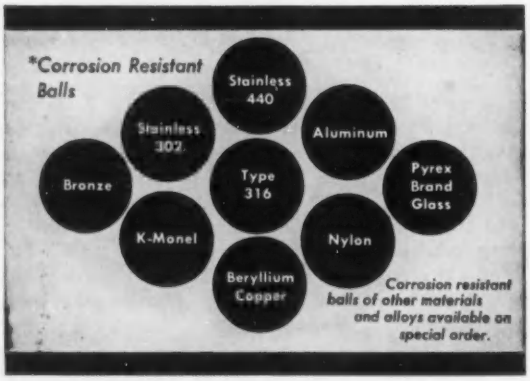
J-M Uneepac comes in a wide range of styles and sizes for many rod and plunger applications. For further information write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Johns-Manville PACKINGS, GASKETS and TEXTILES

If your product uses balls that are subjected to the corrosive action of moisture, gasses, acids, etc. . . . then CRB will solve your headache. We are referring, of course, to the

Corrosion Resistant Balls*

that Hartford has specialized in for many years. CRB's are available in a wide choice of materials . . . the more widely used are listed below. Because Hartford maintains large inventories, prompt shipment can usually be made on CRB's in many sizes. Hartford's engineering service is available to you. Just tell us your problem.



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PRECISION BALLS • BEARINGS

The Hartford Steel Ball Co., Inc., 3 Jefferson Ave., W. Hartford 6, Conn.

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The finest of all top coatings for metal, wood, plaster and masonry surfaces.

Metaz is an epoxy base paint that can be applied by brush or spray to provide a tough, firmly adherent gloss coating. Available in all colors that are consistent with chemical resistance plus black and white.

NOTE! METAZ IS NOT AFFECTED BY

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For technical data, samples and prices write to:

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When to specify Vulcan Electric

CARTRIDGE HEATERS

1. **When application is for:** Complete insertion into machine parts, dies, platens, molds, presses, die blocks of embossing machines, packaging machines, etc.
2. **When specifications call for:** Length — 1″ to 25″ (or longer); diameter — ¼″ to 1-19/64″ (or greater); wattage — 10 to 3200 (or higher); voltage — standard 115 or 230, special 6 to 440; sheath — brass, steel, nickel or high temperature alloys; standard or special lead wires or terminals.
3. **When you have "hot" problems:** Vulcan Engineers are ready to provide special heating units — engineered to your needs. Write for free catalog.

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VULCAN ELECTRIC COMPANY
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Soldering and Branding Irons • Solder and Glue Pots

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BUT GARRETT'S GOT IT FOR QUALITY

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LOCK WASHERS
FLAT WASHERS
HOSE CLAMPS
STAMPINGS

Manufactured by

GEORGE K. GARRETT CO., Inc.
Philadelphia 34, Pa.

Garrett
OF PHILADELPHIA

PRESS PREVIEWS

Sharon Steel to Install $6 million Electric Furnace

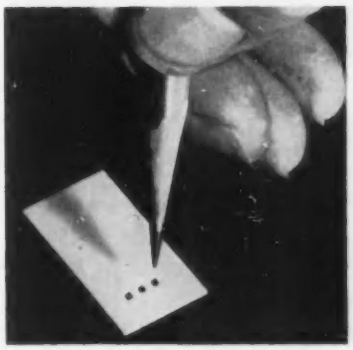
Sharon Steel Corp. will construct a modern $6 million electric furnace shop at its Roemer Works, Farrell, Pa., which is expected to double present capacity of the company to produce stainless and high alloy steel. Construction will be designed for the addition of a second furnace for future expansion.

New Building for Plastics

American Plastics Corp. has begun construction of a new factory building at its Bainbridge, N. Y., plant. The company, a wholly owned subsidiary of Heyden Chemical Corp., has extensive operations in injection molding, extrusion and vacuum forming thermoplastics and fabrication of polyester resins reinforced with fiberglass.

Ultra-Sonic Impact Grinding Service

An ultra-sonic impact grinding service for close-tolerance orifices in the hardest and most brittle of materials is now being offered to industry by the C-Mar Corp., Manasquan, N. J. This service is created to expedite the flow between the design and assembly of components requiring precisioned apertures. High precision in intricate



(Continued on page 467)

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for hydraulic, mechanical and electrical applications

Here is complete information on a versatile modern control of interest to every design engineer. Available in models capable of delivering 50 to 400 inch-pounds thrust, Sperry Hydraulic Remote Controls are used extensively by the automotive, aviation, marine and machine tool industries for manual or automatic control of:

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TO *GOOD* ENGINEERS

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NO SWIMMING POOLS. As an engineering-minded company we place a high value on the skill and ability of engineers. We believe they deserve to be treated with dignity and respect as human beings of a high order—not as commodities to be traded over (and under) the counter.

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NO "BLUE SKY" PROMISES—but a real chance to grow with a growth company (1956 sales over 100 million) dedicated to continued expansion through service to industries basic to America's future: Petroleum, gas, chemical, metalworking, woodworking. No promises of sudden wealth . . .

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limited only by individual ability

Rockwell Manufacturing Company is an engineering-minded company. Our Chairman and our President are engineers. Through engineering we have grown from a one-plant, one-product company to a 100 million dollar a year business operating plants in 20 communities, making 17 basic products covering 25,000 models. And through good engineering we are continuing to grow.

In this environment, there is literally no limit to a good engineer's opportunity for progress. And it is *solid* progress on which to build both professional stature and a satisfying personal and family life. If you are a good engineer with a mature regard for both professional and human values, we'd like very much to talk with you. Interviews can be arranged in practically every section of the United States.

OPPORTUNITIES FOR:

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Metallurgical Engineers
Project Engineers Design Engineers
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Write to: C. A. Wiken, Vice President of Research and Engineering

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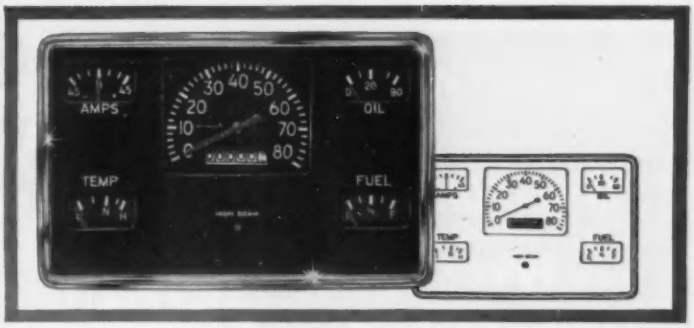
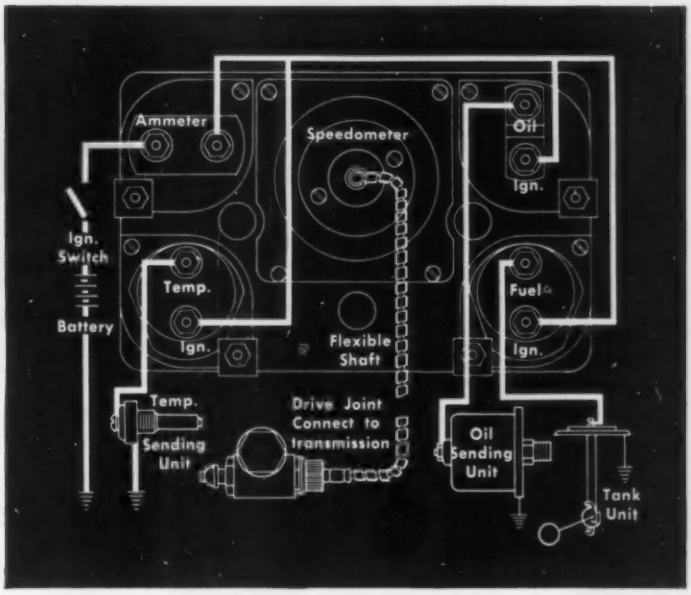
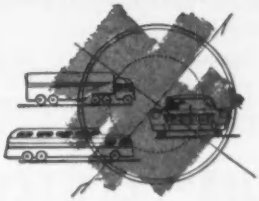
How STEWART-WARNER can help you plan a complete INSTRUMENT PANEL



Stewart-Warner Panel 602-H. A stock panel now used by leading truck manufacturers. Highly flexible—can be fully electric or combination of electric and mechanical.



Typical Hook-up for Panel 602-H. Above panel includes mechanical speedometer, electric gauges, complete with sending units.



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At every step of design—from styling of panel to choosing drive equipment—Stewart-Warner offers you the widest selection . . . plus engineering teamwork unmatched by any other manufacturer!

Stewart-Warner furnishes the most complete line of individual instruments—speedometers, tachometers, tachourmeters—and gauges of all types. Our engineers will help you combine these in one of our many standard panels . . . or an entire panel can be custom-made to your specifications.

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This part, of 18-8 Stainless is used for Aircraft Electrical Harness Assemblies. Formerly made as two separate pieces and brazed—it is now cast in one piece.

Here is the highly efficient way to produce accurate castings with close tolerances. If material and labor costs have you concerned, a careful analysis of your multiple machining operations will point up Investment Casting as your best bet to SAVE UP TO 61% ON LABOR, TOOLING, MACHINING AND ASSEMBLY TIME.

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NEW On-the-Job RECORDS

*TRADE MARK

Every day, earth mover, truck, tractor, grader, shovel, crane, dozer, oil field and power unit operators are establishing NEW on-the-job RECORDS with MORLIFE* CLUTCH equipped machines. They report more continuous hours of heavy-duty, off-highway work, with fewer clutch adjustments, than ever before. Some of the latest records will be featured in the Rockford Clutch booth at the Road Show in Chicago.

"MORLIFE clutch has gone 831 hours without slipping or adjustment."

"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE clutches last 950 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."

"MORLIFE pulls harder and lasts six to ten times longer."

New MORLIFE* CLUTCHES and CLUTCH PLATES Give-

MORE Clutch Life (400% MORE)
MORE Torque Capacity (100% MORE)
MORE Heat Resistance (50% MORE)

Get full information about this record-breaking improvement in heavy-duty clutches by writing Department E.

"Won't buy a unit that isn't equipped with Durable MORLIFE clutch."

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CLUTCHES

orifices, multi-drilled holes, shaping, slicing, and dicing operations is possible because the work is not chipped, spun, heated, stressed or distorted in any way. Ultra-sonic impact grinding employs an electro-mechanical transducer to convert alternating current into mechanical vibrations at the rate of 25,000 cycles per sec. Abrasives are introduced between work and tool face and driven with tremendous impact against the material reproducing an exact counterpart of the tool face. The tool face is never in direct contact with the work. The service has diverse industrial applications ranging from the fabricating of carbide dies to the engraving of decorative glassware.

GE Plans fhp Motor Plant

Fractional horsepower motors for home laundry and electric sink appliances will be manufactured at a new 135,000 sq ft plant to be constructed at Murfreesboro, Tenn., by General Electric Company's Appliance Motor Dept. Completion of the new plant is expected late next year with employment to approximate 500 persons when capacity production is reached. The Appliance Motor Department, headquartered at DeKalb, Ill., is a major producer of fractional horsepower for clothes washers, clothes dryers, dishwashers, and food waste disposers. An extensive expansion program for the DeKalb plant was announced last January including a complete rearrangement and retooling of the existing facilities and the building of additional manufacturing space which in effect doubled the DeKalb capacity. In February the department introduced a completely new appliance motor line designed for use on home laundry and electric sink appliances.

Birdsboro Steel Awarded Contract for Mill Equipment

Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., has been awarded a multi-million dollar contract by United States Steel Corp. for the manufacture of structural steel mill equipment. The new equipment is destined for U. S. Steel's South Works in South Chicago, Ill., one of the largest installations owned by the com-

(Continued on page 468)

FIGHT VIBRATION WITH VIBRATION

How many jobs can a vibration exciter do?

SHAKER SYSTEMS can help you in *at least* five important ways.

Fatigue testing. Shakers have both the range and capacity to determine fatigue limits of structural members, assemblies, aircraft wing and tail structures. Peak forces of up to 25,000 pounds are now obtainable with MB Exciter Systems.

Environmental vibration testing to MIL-E-5272 and other government specifications. This is most important now for assuring reliability of performance in military production. But the same techniques can be used also to improve *all* types of products.

Noise. Just where in a product does it come from and how to eliminate it? An MB shaker helps pinpoint the disturbance by letting you vibrate the product through a whole range of frequencies with the twist of a dial.

Complex wave testing, including random motions. This is something *new!* It subjects a specimen to the same kind of vibration as that encountered in actual service. MB electrodynamic shaker systems offer the frequency range, high acceleration, and freedom from distortion needed for this kind of job.

Production and Quality Control. *Your* ideas are needed here. For example: Someone discovered that size of fine powder particles which sift readily through a screen varies with the screen's frequency of vibration. Permitting easy control of frequency, an MB shaker is capable of working on a *production* line! Tubes too are being production-tested with MB Exciters.

If you need help in putting vibration exciters to work, get in touch with MB . . . leading producer of vibration test equipment.

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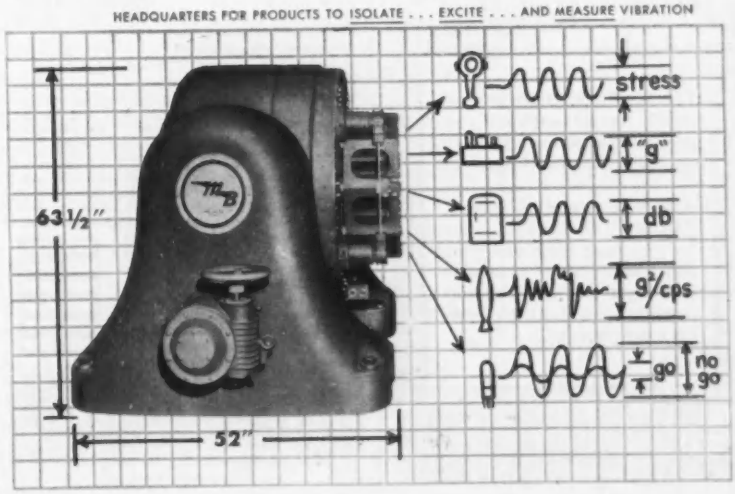
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION



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WITH TOE-TOUCH CONTROL

the drafting table that makes engineering sense

- Increase productivity, efficiency
- Save man-hour costs • Reduce waste motion
- A complete work-station in one unit

Get all the facts—send for illustrated Bulletin 403 and complete Stacor catalog

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"AIRPURE" FILTERS

AIR FILTERS

FOR HIGHLY EFFICIENT DUST CONTROL

"Air Pure" filters developed for atomic energy work are now available for industry. They are the most efficient devices known for the removal of small particles from air and gas streams. "Air Pure" filters may be used for processing foods and medicines, for protection of delicate instruments and wherever bacteria-free and dust-free conditions are required.

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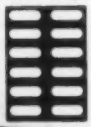
RIVERHEAD 2, NEW YORK

DIAMOND PERFORATED METAL . . on the Socony Mobil Building

New York City's newest, largest and finest metal-clad office building, sheathed with more than 400,000 sq. ft. of patterned stainless steel, is also the largest commercial structure to be, initially, completely air conditioned. On the top three floors, devoted entirely to air conditioning and other mechanical equipment, the wall panels are perforated to permit free passage of air at low velocity.

It was our privilege to perforate the more than 40,000 sq. ft. of stainless steel sheet required for that purpose—under a sub-contract and in accordance with the specifications of the engineers who designed the very modern air conditioning system.

We appreciated, very highly, the opportunity to participate in such an outstanding achievement but are equally interested in any other requirement for perforated metal—no matter how large or small—and have hundreds of specialized tool arrangements which assure prompt accurate service. Catalog 39 contains complete working data and shows many interesting applications in its 32 large illustrated pages. Write, today, for a free copy.



DIAMOND MANUFACTURING CO.
Box 40 WYOMING (Wilkes-Barre Area) PENNA.

West Coast Plant, Diamond Perforated Metals Co.
17915 So. Figueroa St., Gardena, Calif.
Los Angeles Area

pany. Many automatic features will be incorporated in the new equipment, including automatic transfer and turnover devices. The machinery will be used to roll all types of structural steel. Principal elements in the contract are divided into three classifications: a structural mill hot bed and transfer equipment, structural mill straighteners and appurtenances, and structural mill cold saw, shears, gauges and appurtenances.

Tinplate Processing Plant

Plans for construction at Hammond, Indiana of its first plant devoted exclusively to the processing of tinplate have been announced by the American Can Co. Under the "coil strip" program, the plant will receive plate in large coils and then perform several of the operations formerly executed by steel companies. It will to a large extent eliminate the traditional use of precut sheets of plate. The Hammond installation, which is expected to be completed late next spring, is one of Canco's first steps in a previously announced $27 million program for large-scale plate-processing facilities throughout the country.

Mathematics Group at SRI

A new mathematics group has been established by Stanford Research Institute to aid various research programs at the Institute. Activities of the group will include mathematical and statistical consultation as well as instruction of the staff in analog and digital computation. The group, under the direction of Dr. Clay Perry, will make use of an IBM type 650 digital computer.

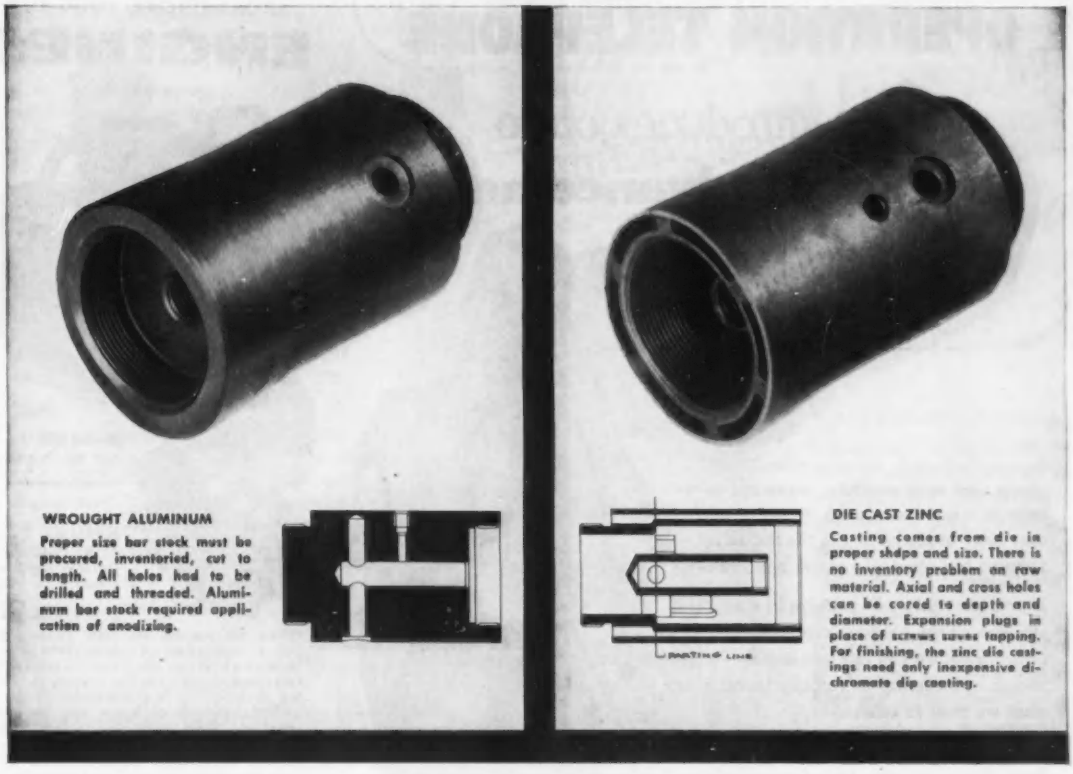
Butadiene Plant Expanded

A multi-million dollar expansion program to increase the output of the world's largest butadiene plant in Port Neches, Texas, by 50 per cent to 300,000 short tons annually, was announced by William P. Gee, president of Texas-U. S. Chemical Co. The company is jointly owned by The Texas Co. and United States Rubber Co. Work on the expansion has already begun and full production from the new facilities is scheduled

(Continued on page 471)

ROCKET FUSE IS REDESIGNED FROM WROUGHT ALUMINUM TO DIE CAST ZINC. RESULT:

50% cost reduction
No increase in weight


WROUGHT ALUMINUM
Proper size bar stock must be procured, inventoried, cut to length. All holes had to be drilled and threaded. Aluminum bar stock required application of anodizing.
DIE CAST ZINC
Casting comes from die in proper shape and size. There is no inventory problem on raw material. Axial and cross holes can be cored to depth and diameter. Expansion plugs in place of screws saves tapping. For finishing, the zinc die castings need only inexpensive dichromate dip coating.

THE SPECIFIC GRAVITY of zinc being 2.4 times that of aluminum, this re-design of an airborne component presents an interesting turnabout. The switch from aluminum bar stock to die cast zinc in the manufacture of the rocket fuse owes its success to the nature of the die casting process. It permits placing the metal where it is needed, eliminating it where it is not. Thus, coring of the zinc die casting has reduced the volume of the fuse body, and the weight was held to 6155 grains—the same as that of the aluminum product it replaces. By producing the fuse as a cored zinc die casting rather than turning it on a screw machine from aluminum bar stock, the following operations were eliminated: 1) cut off, 2) drilling three holes, 3) threading two holes, and 4) anodizing. The zinc die casting requires the following operations subsequent to ejection from the die: 1) trimming flash, 2) cutting two threads, and 3) dichromate dip.

The change, made by Monarch Governor Co. of Willow Run, resulted in a 50% cost reduction. Production rate has been increased from 100 aluminum to 150 zinc die cast fuses in the same amount of time.

DIE CASTING is the Process ZINC the Metal *BUNKER HILL the Preferred Zinc*

BUNKER HILL ZINC

99.99+%

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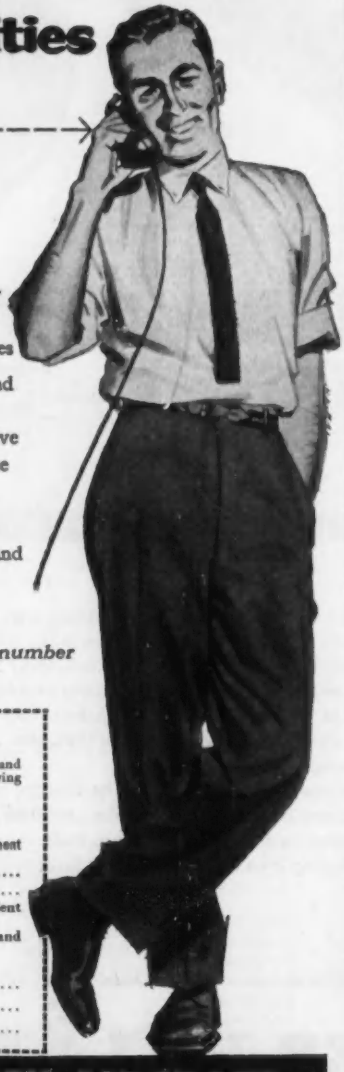
may introduce you to

unusual advancement opportunities



Across the nation, we have talked by phone with men who have expressed interest in our design work. Easily, quickly they have been able to get the important facts on our attractive career opportunities.

If *you* are restless — perhaps in a deadend job — mail the coupon *immediately*. Chances are we will call you shortly — give you an opportunity to verbally investigate what we have to offer.

Ability shows up fast in our design work. Some of our top men, with top earnings and responsibility, are comparatively young. It could happen to you.

Be sure to give us your home telephone number

Mr. E. M. Peterson, Dept. 7, Design Employment
Pratt & Whitney Aircraft, East Hartford, Conn.

I would like to learn more about your openings for product and component designers. My experience has been in the following fields:

☐ Nuclear Design	☐ Aerodynamics	☐ Bearings
☐ Compressors	☐ Hydraulics	☐ Piping
☐ Turbines	☐ Gears	☐ Controls
☐ Structures	☐ Valves	☐ Test Equipment
☐ Afterburners and Related Equipment	☐ Heat Exchangers and Combustion Problems	☐ Test Rigs

Total years Mechanical Design experience .....

You can reach me at ..... Most convenient (home telephone) hours for receiving calls are between .....and .....

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HOME ADDRESS .....

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World's foremost designer and builder of aircraft engines . . . .

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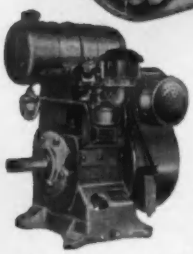
Specify ONAN

SHORT-STROKE, LONG-LIFE

ENGINES



Model CCK
12.9 H.P. 2-cylinder opposed . . . 4-cycle. Gasoline-powered.

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5.5 H.P. One-cylinder. Gasoline-powered. 4-cycle.

Onan short-stroke, air-cooled engines give you a combination of performance characteristics which can add *powerful selling features* to your engine-driven equipment. They are designed for continuous service . . . to run hundreds of hours with minimum attention. Short-stroke, low-friction design, extra-large bearing surfaces, Stellite-faced exhaust valves, solid Stellite exhaust valve seats and many other long-life features give you a big premium in trouble-free service.

Onan engines are compact in all dimensions, light in weight, smooth running and easy starting. They deliver full rated power even under a variety of adverse conditions.

If stepped-up performance will sell more equipment for you, you can build in this extra saleability with Onan engines at no extra cost. Write us or call.

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Lightweight, air-cooled Onan Diesel engine

Model DRP
Two-cylinder, opposed. 15 H.P. at 2300 R.P.M. 4-cycle. Solid injection, full Diesel. Electric starting. 12-volt generator. Full pressure lubrication.

Onan
ELECTRIC PLANTS

ONAN
AIR-COOLED
ENGINES

for fall of 1958. The Port Neches butadiene plant was purchased from the government by Texas-U. S. Chemical Co. and Goodrich-Gulf Chemicals, Inc. in May of 1955. It had a rated production capacity of 190,000 short tons and was the largest constructed under the government wartime synthetic rubber program.

Research Facilities for Rare Earths

An expansion in the research facilities of Michigan Chemical Corp. of Saint Louis, Mich., will consist of a series of new laboratories to be used expressly for research and production control of products and processes of the company's rare earths business. Developing from pilot plant work based on research investigation, this division of Michigan Chemicals has been progressing steadily. The importance to the company and to its rare earths customers prompted the board of directors' move to provide the additional staff, scientific equipment and library facilities.

Expansion in Silicone Products

International Packings Corp. has started a two-year expansion program for their plant in Bristol, New Hampshire. Initial plans call for a special department to manufacture custom-designed silicone and synthetic rubber products for the automotive, appliance, hydraulic and other industries. The first unit will comprise 10,000 sq ft of manufacturing space and utilize all new machinery. Eventually, construction will include a new office building, complete facilities for engineering and laboratory personnel, manufacturing space for both leather and synthetic packings, oil seals and precision molded products.

Clark Controller Establishes Los Angeles Manufacturing Operation

Clark Controller Co., manufacturers of industrial electrical control equipment, has occupied a 10,000 sq ft building in Los Angeles, Calif. The building will include the former Los

(Continued on page 473)

We at Newark have many years' experience in the production of quality wire cloth. But we haven't stopped there. One division of our company is fully equipped and staffed to fabricate *any* part you need with a wire cloth insert.

We have experienced engineers ready to assist yours in the design of the part to assure making the best and most economical use of the mesh insert. And, we have the facilities and skilled personnel to fabricate the parts to your strict specifications in small lots or in production quantities to meet your production schedules.

It will pay you to investigate how you can take advantage of our experience in wire cloth manufacture and parts assembly. We shall be glad to quote on your requirements. Let us have complete details on specifications.

NEWARK for ACCURACY

We can furnish wire cloth woven from all commercially used metals. Sizes range from 4 inches (space cloth) to 400 mesh.
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AERONAUTICAL

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APPLIANCES

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STALWART *Silicone* RUBBER PARTS

FOR HIGH TEMPERATURE APPLICATIONS. Industry is solving problems and cutting costs with SILICONE RUBBER PARTS by STALWART. Because newly developed compounds now retain desirable rubber-like qualities at temperatures up to +600° F., they are recommended for applications where temperatures destroy ordinary rubbers.

FOR LOW TEMPERATURE APPLICATIONS. Silicone Rubber parts by STALWART are capable of withstanding temperatures as low as −130° F. without becoming brittle. They have excellent dielectric properties and resist compression set, oxidation, ozone and many chemicals.

Let STALWART . . . specialists in custom fabrication of precision SILICONE parts . . . solve your design problems.

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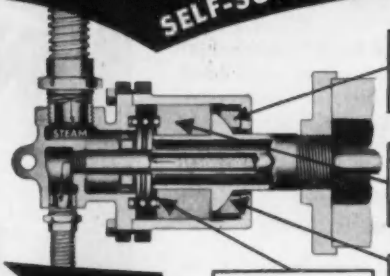
STALWART RUBBER COMPANY

Manufacturing Plants in Bedford, Ohio and Jasper, Emerys
Main Offices—100 Northfield Rd., Bedford, Ohio

7127-SR

JOHNSON Rotary Pressure JOINT

SELF-SUPPORTING TYPE



1. SEAL RING — of special carbon-graphite. Eliminates packing and oiling.

2. GUIDE — Also of carbon-graphite. Makes joint self-supporting.

3. NIPPLE — Rotates with roll, seals against ring.

4. SPRING — For initial seating only. In operation joint is pressure sealed.

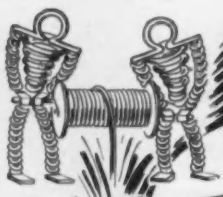
Only 4 Internal Parts

For introducing steam and liquids into rotating rolls and cylinders, there's nothing like the Johnson Joint above. It's packless, self-lubricating, self-adjusting, self-supporting. It has been adopted by dozens of machinery makers, and is finding new uses every day.

Type SB shown handles both steam and condensate through same head; also available for through flow service, and in sizes and styles for all operating conditions. ***Write for literature.***

The Johnson Corporation

813 Wood St., Three Rivers, Mich.



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4014 W. Grand, Chicago 51, Ill.

FILTRATION NEWS

Filter to 900°F... anywhere!

PORO-KLEAN gives designer new freedom in filtering hot, hi-pressure fluids

"Versatile" is the word for Cuno's PORO-KLEAN filters when it comes to providing 3-30 micron filtration in hot spots and tight places!

In a tremendous variety of sizes and shapes, these new porous stainless steel filters are everywhere pushing back the temperature and pressure frontiers in micronic filtration. The reason: PORO-KLEAN'S unique combination of physical properties. Its high strength, exceptional heat and corrosion resistance and adaptability to a wide variety of shapes makes it easy to apply both in industrial processing and in compact aircraft and missile hydraulic systems.

For instance take the tiny preformed shapes shown above. They are: cylinder (1), cup (2) and cup with lip (4)—all used to protect micro-finished aircraft hydraulic servo valves; disc (3) for oil filter, cylinder (5) with brazed-on seat for hydraulic O-ring; disc (6) for gas-turbine fuel-oil nozzle; cup (7) and (8) for diesel fuel-oil nozzle.

And, for the big jobs, you can get single or multiple PORO-KLEAN units like the 54-inch element (below, right). It's designed to filter synthetic polymer in a chemical plant with 1500 psi pressure drop and operation at 550°F.

If you have a tough filter problem, get all the details on Cuno PORO-KLEAN. You can be sure it will fit into your design. Write: The Cuno Engineering Corporation, 20-11 South Vine Street, Meriden, Connecticut. 6.2

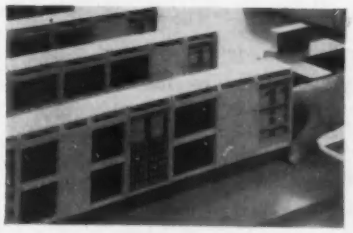
CUNO ENGINEERED FILTRATION

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

Angeles District Sales Office as well as a new engineering and manufacturing department. The Los Angeles plant will be the first control manufacturing operation conducted outside of Cleveland by the Clark Controller Co., although an affiliate manufactures control equipment at Toronto, Canada. The company designs and manufactures standard control items such as motor starters, contactors, relays and limit switches; and designs and manufactures standard and specially engineered control systems for individual machines, material-handling equipment, and industrial processes.

Scale Model Processing System

A detailed scale model, weighing less than 50 lb is the first step of a $1.5 million data processing system developed by Datamatic Corp., Newton Highlands, Mass. The primary



reason for making the model was for use in planning floor layouts of finished installations; use of a scale model permits easy location or re-location of various segments. Because actual construction of the system involved many thousands of man-hours, the scale model has been used to additional advantage as a sales tool in explaining system layout as it applied to customer requirements.

New Induction Vacuum Melting Department

A new induction vacuum melting department has been completed by Allegheny Ludlum Steel Corp. at its Watervliet, N. Y. Works. The new facility is temporarily being used as a research and development project; however, it is to be converted to regular production status as soon as research studies now under way are

(Continued on page 475)

CORED SIGMA BLADE

1500 lb. stainless steel sigma blade not only has to be corrosion resistant and dimensionally accurate, but a 1½" cored hole, centrally located with respect to the various cross sections is required throughout its length

The full story is told in Cooper Alloy AKH #4.

KEL-F LINERS FOR VANTON PUMPS

The addition of Kel-F to the long list of rubbers and plastics now available for liners makes the Vanton pump suitable for handling such media as fuming nitric and other strong oxidizing acids, mineral acids, alkalies, aliphatic solvents and hydraulic fluids.

Details on request.

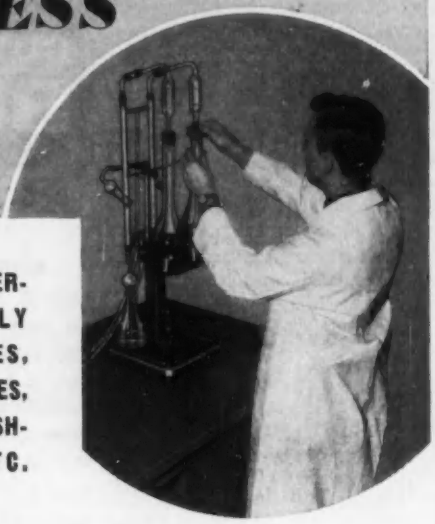
STAINLESS STEEL RETARDERS

Cooper Alloy stainless steel retarders in the Cyclotherm Generator help to produce additional heat transfer with maintenance-free reliability. Known as Cyclotherm Cyclonic Combustion the new principle delivers a guaranteed 80% heat transfer in two passes and drops maintenance costs as much as 50%.

COOPER ALLOY
CORPORATION • HILLSIDE, N.J.

THIS MAN MEANS BUSINESS

Chief Sandusky



FERROUS AND NON-FERROUS CENTRIFUGALLY CAST ROLLS, SLEEVES, TUBES, LINERS, CHUTES, RETORTS, RINGS, BUSHINGS, BEARINGS, ETC.

His business is product improvement. He's your assurance that every centrifugal casting which leaves our plant has been scientifically developed and quality checked through every step of its production.

Creative research has been the backbone of Chief Sandusky customer service for over forty years. That's why today's ferrous and non-ferrous centrifugal castings are the finest available.

When your needs, either standard or special, call for close-grained cylindrical castings that must resist heat, corrosion, or abrasion, make it your business to call Chief Sandusky. Our technical aid is as close as your phone.

An additional service is machining facilities for turning, boring, and drilling.

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Build your design skills

Your guide to better, more serviceable electronic equipment

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MECHANICAL DESIGN FOR ELECTRONICS PRODUCTION

Helps you design electronic equipment with most durability at least cost—explains layout, materials, and processes, especially as they affect good electronics manufacture. Also helps production men work more closely with electronics designers.

Covers such subjects as sheet-metal work, machining operations, shielding, use of sealing compounds, motor characteristics, etc. Also such related topics as mechanized assembly and efficient packaging. By John M. Carroll, Assoc. Edit., *Electronics*. 348 pages, 172 illus., $6.50

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VIKING supplies the Oomph

One little Viking Pump supplies the hydraulic power to raise this lift up to 38 feet. The stand can be raised, lowered or stopped at any level from the ground or stand, simply by starting or stopping the electric motor-driven pump.

Used in motion picture studios for lighting equipment and camera work, this lift is manufactured by Hamlin Hydraulic Lifts, Monrovia Machine Works, San Gabriel, California. They also make portable hydraulic lifts for factory maintenance crews, storage room stackers, scaffolding stands, light bulb changers, orchard sprayers, casket lifts, and many others. Hamlin has built these lifts for more than 20 years, and has included Viking Pumps as an integral part of each unit. If you're looking for positive, dependable pumping, learn more about Vikings. Write for Bulletin Series 56S X.

VIKING PUMP CO.
Cedar Falls, Iowa U.S.A.
In Canada it's "ROTO-KING" Pumps
See our catalog in Sweets

completed. The new facility will complement the vacuum remelting department installed at the same location last year. Research and development programs are in progress on high temperature wheel and bucket alloys for gas turbines. High temperature bearing steels, tool steels, alloys for magnetic applications and alloys for specialized corrosion service are also being studied. The induction vacuum furnace incorporates a 300 lb furnace in its research and development configuration, and as a production unit will utilize a 2000 lb furnace. Two additional consumable electrode vacuum remelting furnaces have also been completed at the Watervliet plant. The units will double the capacity of the remelting department which went into operation in October of 1955.

Addition to Coupling Plant

The construction of an addition to the plant of the Ajax Flexible Coupling Co. Inc. at Westfield, N. Y., will be completed in November. This addition will be located on the company's 22-acre site and will increase the production of dihedral gear type and rubber-bronze bushed flexible couplings.

Vanadium-Alloys Steel Announced Expansion Program

The Vanadium-Alloys Steel Co. announced an expansion program of its mill at Latrobe, Pa., which will approximately double the plant's capacity of high speed steel. Plans call for the extension of existing buildings adding 52,000 sq ft of space to the structures housing the rolling mills, hammer and melting shops. The expansion program will include the installation of 10, 12, and 16 in. rolling mills. It is expected the new facilities will be in operation in 14 months.

Aluminum Company Expands

Kaiser Aluminum & Chemical Corp. has begun expansion of their Newark, Ohio, rod, bar, wire and electrical conductor works. The capac-

(Continued on page 477)

Choosing the carbon brushes that are supremely suited to your requirements is easy when you have the book that tells you all about brush characteristics and applications. Covering brushes for every type of fractional horsepower, automotive, aviation and industrial application, it represents 50 years of carbon and brush leadership. Its title? "Brushes by Speer."

The coupon below will bring you your copy with our compliments.

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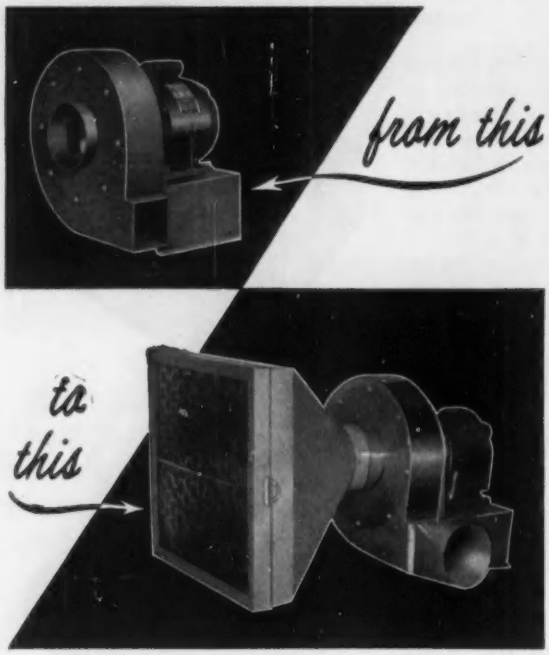

. . . And Peerless® Solves Another Electronic Gear Cooling Problem!

• This large aircraft manufacturer needed blowers to cool and ventilate stationary and airborne electronic gear. Peerless PW-12 Pressure Blowers were selected. Square-to-round discharge adapters with intake filters were fabricated to provide dust-free air. We are working continuously with many of the nation's top producers and users of electronic equipment. They know we design and build our own fans and blowers . . . motors and all. That's why we can unconditionally guarantee their dependable performance. From start to finish we have complete control of our product. Our engineers can work to your specifications to produce the fans and blowers that enable your equipment to operate at its best.

Write, wire or phone us now!
Ask for Bulletin SDA-160.

FAN AND BLOWER DIVISION
THE Peerless-Electric® COMPANY
FANS · BLOWERS · ELECTRIC MOTORS · ELECTRONIC EQUIPMENT
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NICOTE Metallized Ceramic Coating

...for use with both hard and soft solders!

NICOTE is Frenchtown's new exciting discovery . . . a *single* metallic coating for refractory ceramic bodies which provides a surface for applying solders with melting points between 275° and 1600°. With NICOTE, no buffing, electroplating or tinning is necessary in most applications to form a strong, firmly-adhering bond with either *hard* or *soft* solders. NICOTE's mechanical bond makes it ideal for hermetic seals, high strength mechanical seals, and vacuum applications. Bulletin 155 contains complete engineering details. Write for a free copy today!

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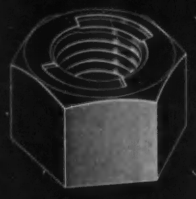
LESS torque-scatter WITH THE

M·F



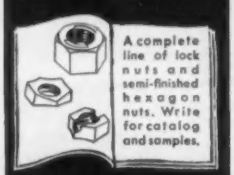
Uni-Torque® **LOCK NUT**

(Production men, of course, know that a lock nut with a "scatter-pattern" interrupts production and increases rejects.)

. . . *and* constant-torque M-F costs NO MORE!

Why do *designers* want a lock nut that shows an *even* pattern of torque, nut *after* nut, keg *after* keg?

Because it means *uniform bolt tension*, which is important in keeping the finished product true to original design.



A complete line of lock nuts and semi-finished hexagon nuts. Write for catalog and samples.

MAC LEAN-FOGG

Lock Nut Company

5535 N. Wolcott Street
Chicago 40, Illinois

ity of the plant is expected to be increased by 23,500 tons of mill products annually. The 5½ million dollar expenditure for Newark will cover production equipment, alterations to existing equipment and a new building to house warehouse, shipping and laboratory facilities. New equipment to be purchased will include stranding machinery, wire drawing equipment, a flat wire rolling mill, insulating equipment, and increased testing facilities.

Radiation Physics Laboratory to be Built

Plans to construct a $2 million radiation physics laboratory at the Experimental Station, Wilmington, Del., were announced by the Du Pont Co. The new laboratory, to be operated by the company's Engineering Dept., will be staffed by a group of radiation specialists. It will provide additional facilities for long-range research on the measurement of radiation and its absorption in various materials. The two-story structure will have electrical equipment to generate a variety of high-energy, atomic-type particles and rays. Construction is scheduled to start immediately with completion due by January of 1958.

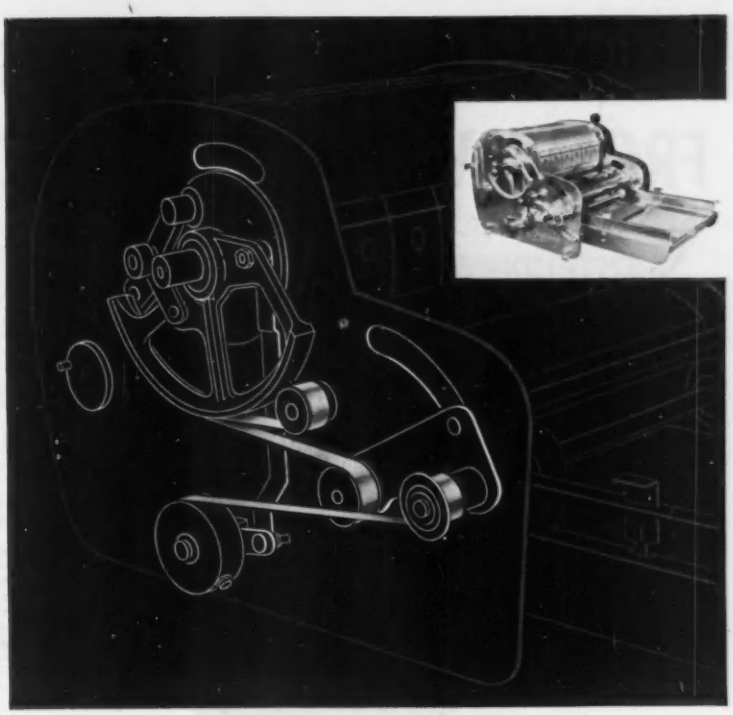
Expansion in Atomic Products

General Electric's Medium Induction Motor Dept. has announced a $2-million expansion in Schenectady, N. Y., for the manufacturing and testing of canned motor and electromagnetic pumps for the atomic industry. Primary use of the pumps is to circulate liquid metal used as a coolant in nuclear reactors. Department officials said the electromagnetic pumps are a definite step forward in the pumping of metallic or other conductive fluids, because they eliminate the need of moving parts such as impellers, shafts and seals.

New Ceramic Plant

Erie Resistor Corp. of Erie, Pa. is building a ceramic plant in State College, Pa. which will be known as

(Continued on page 479)



Transmit Motion Without Backlash

USING A NEG'ATOR® SPRING

Quiet, gearless transfer of motion without slippage or backlash—still another function of Hunter's versatile design component, the NEG'ATOR constant-tension Spring.

Searching for a gearless method to link and synchronize the action of paper handling rollers to the timing drive assembly on the new "ROCKET" duplicating machine, design engineers at Standard Duplicating Machines Corp. tried cords, cables, chains—found that NEG'ATOR Springs outperformed all.

So, as illustrated, they attached the free ends of two NEG'ATORS to the cam-and-lever driven timing segment and the free end of a third NEG'ATOR to an idler pulley. The constant tendency of the NEG'ATORS to return to their original coiled condition when extended keeps them taut—eliminates backlash. They rewind smoothly on the drive pulleys as the pulleys are returned, under spring tension, to the cycle starting position.

By replacing gear trains with NEG'ATORS, Standard's engineers obtained efficient operation, longer life, quieter operation, and reduced unit cost. The "ROCKET" is said to be the "quietest machine on the market."

Used in the manner described or to counterbalance without mass, maintain constant pressure, deliver retracting force, power portable units, expand a scale, or perform other functions, the constant-tension NEG'ATOR Spring might offer just what you're looking for.

You can learn more about the NEG'ATOR, its characteristics, forms, functions, and applications by reading Bulletin 310N. Send for a copy.

HUNTER SPRING COMPANY

5 Spring Avenue, Lansdale, Pennsylvania

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INDUSTRY LEARNS FROM AVIATION...

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ENVIRONMENTAL IMPROVEMENT *through* ENGINEERING
MET-L-FLEX

Precision Flex O Press mounted on Robinson Model W339 Machine Tool Mountings.

Robinson success in the exacting job of protecting delicate electronic controls in aircraft has put industry wise to the value of applying the same protection to machinery.

When you put a machine on Robinson all-metal industrial mounts, you accomplish three things.

- ***First,*** you lengthen machine life and increase and improve its performance.
- ***Second,*** you decrease machine sound and vibration transmission to and from the floor (and to your workers.)
- ***Third,*** you provide for machine mobility when needed, with none of the time and labor expense of lagging the machine to the floor.

Send for bulletin 1000

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TETERBORO, NEW JERSEY
Vibration Control Engineers
INDUSTRIAL DIVISION

WEST COAST ENGINEERING OFFICE
3006 WILSHIRE BLVD., SANTA MONICA, CALIF.

Light Metals Design Tips

Magnesium Finishes Comparison Chart

FINISH	COST (10=greatest 1=least)	ADHESION (10=greatest 1=least)	CORROSION PROTECTION (10=greatest 1=least)
Bare magnesium + proprietary paint (C)	1	1	1
Bare magnesium + etching primer (B) + finish paint	2	3	2
Dow #1 + zinc chromate primer (A) + finish paint	3	3	4
Dow #1 + etching primer (B) + finish paint	3	4	3
Iridite #15 + zinc chromate primer (A) + finish paint	3	3	5
Iridite #15 + etching primer (B) + finish paint	3	4	
Dow #7 + zinc chromate pri... (A) + ...			

NEW CHART SHOWS COMPARATIVE COST, ADHESION, CORROSION PROTECTION OF MAGNESIUM FINISHES

The partial chart shown above describes some common finish systems used for magnesium. Considered are costs, adhesion and corrosion protection.

Performance of magnesium in any environment depends not only on the medium, but also on service conditions. For example, in normal inland atmospheres, magnesium possesses surface stability superior to many other metals in common use. Bare magnesium develops a characteristic thin gray film commonly consisting of a mixture of hydrated magnesium oxide and carbonate. For many commercial applications this gray film functions suitably without finishing. In other environments, chemical treatments, anodic treatments, painting or plating are used if sales appeal and service requirements make them necessary.

Write for your free copy of the complete Magnesium Finishes Comparison Chart or for help on any magnesium finishing question. Whatever your light metals problem . . . count on Magcoa engineering counsel and fabrication facilities.

MAGNESIUM COMPANY OF AMERICA
LIGHT METAL FABRICATION DIVISION • EAST CHICAGO 27, IND.
magcoa

FOR POSITIVE, LOW-COST *SPROCKET DRIVES...*

TRY GENUINE BEAD CHAIN

Now successfully employed in radio and TV tuners, recorders, air conditioners, timing devices, etc. Designed for economical, positive gear trains or drives free of slippage and backlash.

VERSATILE BEAD CHAIN
has many other advantageous applications such as:

- part retainers
- remote control devices
- fan or ventilator pulls
- revolving displays

and many others

WRITE TODAY FOR CATALOG AND SPECIFICATION SHEETS

THE BEAD CHAIN MFG. CO.
92 Mountain Grove St., Bridgeport, Conn.

Technical Ceramics. The new plant will house the latest equipment for mass producing quality ceramic dielectrics and other special ceramic parts; much of which has been custom designed. The first floor will be utilized by production and the general offices, while the second floor will house research and engineering laboratories. The plant will be air conditioned and have controlled humidity to insure quality and uniformity for the production of ceramics.

Beryllium Production Increased

The Atomic Energy Commission has awarded a $23 million contract to the Beryllium Corp., Reading, Pa. requiring the production of 500,000 lb of nuclear grade pure beryllium metal over a five year period. Until recent years, the beryllium industry has been dependent upon beryllium copper alloys sold in cast and wrought form. With the development of atomic energy, the metal beryllium has become increasingly important. The large amount of tonnage to be produced for the AEC under this contract may stimulate new applications for the metal, which in turn will substantially reduce the cost of pure beryllium to both industry and government. Beryllium Corp. officials predict that expanded research efforts created by the new contract will so improve the technology of fabrication that further cost reductions can be expected.

Liquid Air Plant For West Coast

An air liquefaction plant costing $7,500,000 will be built in the Los Angeles area by the Air Reduction Pacific Company, Inc. The new plant, scheduled for completion in late 1957, will have a daily production of 55 tons of high purity liquid oxygen, 15 tons of liquid nitrogen, and 3½ tons of liquid argon. The Los Angeles plant will be the fourth air liquefaction plant of the Air Reduction Co., Inc.

The plant will serve the aircraft, steel, metal fabricating, chemical and food processing industries. Uses for oxygen include steel producing, foun-

(Continued on page 481)

The new **ROPER**
HYDRAULIC PUMP-MOTOR
for Improved **INDUSTRIAL SERVICE**

Designed by the same engineers who developed the famous Roper Rotary Pumps, the new Roper Hydraulic Pump-Motors operate on the same principle using two equal size, smooth-running gears in a precision-fitted case. These units offer low-speed and high-torque (much needed in the hydraulic field), and their versatility finds them well-suited to heavy-duty service within their operating range. They run equally well in either direction both as pumps or motors . . . they can be direct-connected without speed reducers, thus conserving space . . . they are easily installed, easy to operate, and are long on economy. Perhaps *you* have equipment that can be further improved with a Roper Hydraulic Pump-Motor. Send for all the facts today.

PERFORMANCE CHARACTERTISTICS

Available in foot and flange mounted models. Recommended speed range on larger sizes is from 200 to 800 RPM with pressures to 800 PSI In this range, Roper units require from 7 to 40 GPM flow and will develop up to 11.5 HP output at maximum speed and pressure. Smaller sizes may be operated up to 1200 RPM and up to 800 PSI which will require a flow of 16 GPM to develop up to 5 HP.

SEND FOR BULLETIN 22

ROPER
Rotary Pumps

GEO. D. ROPER CORPORATION • 381 Blackhawk Park Ave., Rockford, Ill.

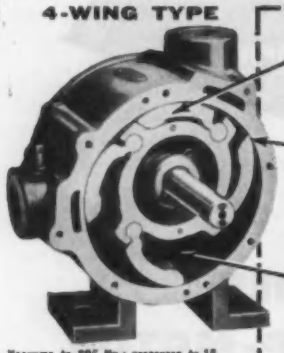
Exclusive Features of

LEIMAN Rotary Air and VACUUM PUMPS

bring you

★ High Vacuum
★ Greater Volume
★ Smaller Size
★ Lifetime Operation

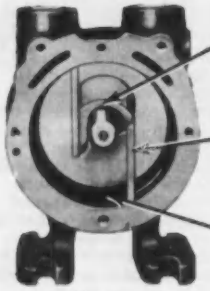
4-WING TYPE



- Curved Wings on easy-action hinge, maintain continuous wall contact.
- Cast Iron Wings and Cylinders hone themselves to hard, glassy smoothness—take up their own wear—assure leak-proof seal for years.
- Extra-large Air Space provides greater capacity, permits use of smaller pump.

Vacuums to 20" Hg.; pressures to 15 psig.; displacement to 162 c.f.m.

2-WING TYPE



- Automatic Wing Adjuster assures wing-to-wall contact, prevents sticking, guarantees positive action.
- Extra-long Steel Wings (not composition) provide long wear. Cylinder walls made of durable cast iron.
- Large air space provides more compact pump.

Vacuums to 29.9" Hg.; pressures to 20 psig.; displacement to 40.8 c.f.m.

Install LEIMAN AIR PUMPS

for dependable Vacuum (Suction) and Pressure

FREE ENGINEERING DATA

- *Application Book* showing 60 "how-to-do-it" blueprints of actual applications.
- *16-page Catalog* showing construction, types, sizes, capacities, etc.

Precision-made, compact Leiman Air Pumps have fewer moving parts — no tips or blades to renew — need no maintenance except occasional oiling — run for 10, 15 and 20 years without trouble or shutdown. Over half a million installed. Consult our engineers on any air application.

SEE OUR CATALOG IN SWEET'S FILE

LEIMAN BROS., Inc.

107 Christie St., Newark 5, New Jersey

in Wheels, too...

TWO Do the Job BETTER THAN ONE!

USE DUAL ALLIED WHEELS

In Place of ONE Larger, Expensive Wheel!

Gain These Advantages:

- **LOWER COST**—Reduce wheel cost! Buy Dual wheels for less than one single conventional type!
- **GREATER FLOTATION**—More tire surface on the ground. Spreads load suspension!
- **EQUAL or GREATER LOAD CAPACITY**—Load weight is distributed!
- **BETTER TRACTION**—On wet or dry surfaces; more tire gripping area!
- **DESIGN DISTINCTION**—More substantial appearance! Offers new design possibilities!

STOCK SIZES, TYPES — Or CUSTOM BUILT!

ALLIED Wheel Products, Inc.

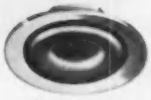
Dept. PE • 27 Broadway • Toledo 4, Ohio

SLASH ASSEMBLY COSTS

on light sheet metal assemblies—parts—components—mouldings—ornaments, etc.

Washer Type PALNUT Lock Nuts (above) replace ordinary nut, lock nut and flat washer—cost much less—save parts and handling—apply fast with hand or power tools—provide resilient spring locking action that keeps assemblies tight. Specialized variations shown below.

One-piece lock nut and flat washer replaces two, three, even four parts according to application.



Sealer Type
Integral plastisol compound seals out water and dust, eliminates extra sealer washer.

Spacer Type
Spans bosses or protruding elements; eliminates extra cup washer.

Grounding Type
Depressed teeth in base cut thru non-conductive coatings to provide electrically grounded assembly.

Write for details and free samples, outlining assembly requirements.

THE PALNUT COMPANY

Subsidiary of United-Carr Fastener Corp.

65 Glen Road, Mountainside, N. J.

Canada: P. L. Robertson Mfg. Co., Inc., Milton, Ont.

WASHER TYPE PALNUT® LOCK NUTS

Endurance Rated
ELECTRIC COUNTERS and ACTUATORS
to Fit every need

200,000,000 COUNT LIFE

PIC
SUPER-WIZARD

1000 CPM.
5 watts input.
Balanced Armatures.
4 and 6-digit models in basemount, panelmount and dustproof enclosed types for 60, 40-50, 25 cycles and DC; all voltages to 230.
Purchase cost only 18c per million counts.

50,000,000 COUNT LIFE

PIC
600

1000 counts per minute
7 watts power consumption
Balanced armature
Quiet operation. No AC hum.
Tamper proof housing.
Lubrication not required.
Available in basemount and panelmount models—also to count dozens, for 60, 40-50, 25 cycles and DC; all voltages to 150.

6,000,000 COUNT LIFE

PIC MERCURY
4-digit Reset

600 Counts per minute.
3 watts power input.
4-digit Basemount and Panelmount models also to count dozens — all voltages to 115, AC or DC.

3,000,000 COUNT LIFE

PIC MERCURY
5-digit non-reset

600 Counts per minute.
3 watts power input.
Tamper proof construction.

See your PIC Representative or write

PIC
PRODUCTION INSTRUMENT CO

702-10 W. Jackson Chicago 6, Illinois

dry, aircraft, shipbuilding and metalworking industries. Nitrogen is used in chemical, electronics, and food processing as an inert atmosphere. Argon is used primarily in inert gas shielded arc welding processes.

New Divisions

Greer Hydraulics, Inc., Jamaica, N. Y., has established a Research and Development Div. to be headed by Jules Kendall. The new department will work on guided missile systems.

Tipp Mfg. Co., Tipp City, Ohio, has established a new Controls Div. to manufacture and distribute electrical industrial controls.

Westinghouse Electric Corp., Pittsburgh, Pa., has created an Industrial Gas Turbine Dept. at their plant in Lester, Pa.

Arnolt Corp., Warsaw, Ind., has opened a new Aeronautical Div. in Los Angeles, Calif. According to company officials, the new facility is expected to increase the aviation products volume by 50 per cent.

Sharon Steel Corp., Sharon, Pa., has appointed Louis K. Whitcomb as head of a new Market Research Div. Emphasis will be placed upon the development of broader uses of the company's products by the metal working field.

Waters Mfg., Inc., S. Sudbury, Mass., has announced the creation of an Electronic Components Div. manufacturing a standard line of coils, chokes, condensers, etc.

Sheffield Corp., Dayton, Ohio, has established a Research and Development Div. devoted exclusively to instruments and systems for autometrology.

Aircraft Products Co., Bridgeport, Pa., has set up two new divisions: Tactair Valve Div. will manufacture and distribute precision valves, hydraulic and pneumatic components; the Tactair Autopilot Div. will produce a new line of autopilots.

Norton Co., Worcester, Mass., has established three new divisions: Abrasive Div., headed by John Jeppson; a Refractories Div., headed by Wil-

(Continued on page 483)

New manufacturing process improves performance of CHROMALOX Electric Strip Heaters

An improved manufacturing process, combined with a newly developed refractory material, offers you the finest performance in strip heaters. Rugged and long lasting, they are industry's workhorse among heating elements.

So when you use the improved line of Chromalox Electric Strip Heaters, you're assured of even better performance in the heating of platens, dies, kettles, tanks, ovens, air ducts and other applications that require dependable, accurately controlled heat . . . where and when heat is needed.

Let the Chromalox Sales-Engineering staff solve your heating problems—electrically.

Write for your copy of Catalog 50

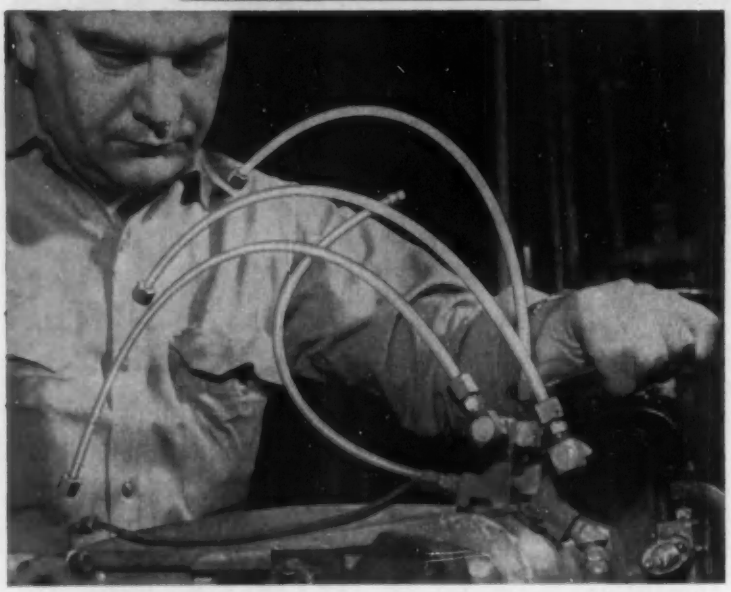
This data-packed catalog covers the design, uses and prices of the complete line of Chromalox Electric heaters, elements, thermostats, contactors and switches.

To get short factual material on many additional applications of electric heat, send for Booklet F1550 "101 Ways to Apply Electric Heat."

Edwin L. Wiegand Company
7535 Thomas Boulevard, Pittsburgh 8, Pa.

EDWIN L. WIEGAND COMPANY
7535 Thomas Boulevard, Pittsburgh 8, Pa.
I would like to have—
☐ a copy of Catalog 50
☐ a copy of "101 Ways"
☐ a Sales-Engineer contact me
Name
Company
Street
City Zone State
A-4454A

PRESSURE **NYLAFLOW**® TUBING



High-strength, flexible *Nylaflow* simplifies installation problems

● No other tubing material offers the same combination of desirable properties for oil and lubrication lines, air lines, food and beverage lines, vacuum lines, etc.

● Nylaflow Pressure Tubing *is* different. It's made from a tough, horn-like polyamide, with these superior advantages:

ALMOST UNLIMITED FLEX LIFE—minimum fatigue from vibration and continuous flexing.

HIGH STRENGTH—highest strength per weight ratio of any extruded plastic tubing with corresponding high burst strength.

CRUSH RESISTANT—accidental impact won't dent or crush Nylaflow.

CORROSION RESISTANT—impervious to hydro-carbons and practically all solvents.

LOW INSTALLATION COST—use Nylaflow with standard fittings. It requires no pre-bending, is easily worked from light, compact coils. Eliminates intermediate fittings and flexible couplings.

PERMANENT FORMING—lines can be pre-bent to permanent position.

● Nylaflow is processed under the most rigid controls to assure highest quality and absolute uniformity. It is available in short-time burst pressures of 1000 psi. and 2500 psi. and in a variety of sizes and coil lengths. Write today for latest test and application data or information on how Nylaflow can solve your tubing problem.

THE POLYMER CORPORATION OF PENNA. • Reading, Penna.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO Nylon, Teflon†, Q-200.5 (cross-linked polystyrene) and K-51 (chlorinated polymer)

†DU PONT TRADEMARKS

REMEMBER WHEN?

The oil soaked streak down the middle of every road . . . the oil puddle on the garage floor . . . busted shafts and burned bearings due to lost lubrication?

Universal Oil Seals changed that picture . . . solved these problems efficiently and economically. There's a Universal seal to fit YOUR requirements too. Over twenty-six years of specialized oil seal engineering at your service.

We invite your inquiry.

UNIVERSAL OIL SEAL CO.

P.O. BOX 74
PONTIAC 12, MICH.

liam G. Fallon; and a Electro-Chemical Div., headed by Howard J. Daly.

Harvey Machine Co., Torrance, Calif., has established an Aluminum Structural Div. to engineer, fabricate and erect aluminum structures. Dr. J. M. English will head the division

New Motion Pictures

All films are 16 mm, color and sound unless otherwise noted.

"The Petrified River. . ."—28 min. This film covers the story of uranium in the United States from prospecting for ore to the peaceful uses of atomic energy. Loaned free from the Graphic Services Section, U. S. Bureau of Mines Experiment Station, 4800 Forbes St., Pittsburgh 13, Pa.

"Transformers in the Making"—28 min. Progressive steps in the manufacture of power and distribution transformers are shown. Loaned free from Wagner Electric Corp., 6400 Plymouth Ave., St. Louis 14, Mo.

"Quality Unlimited"—30 min. The film shows the production of wire rope from basic steel making to the testing of the finished rope. Colorado Fuel and Iron Corp., 575 Madison Ave., New York 22, N. Y.

"The Science of Making Brass"—29 min. The movie explains the process of making brass and other copper alloys in the forms of sheet, rod, wire and tube. This picture recently won first prize for technical films at Turin, Italy. Loaned free by Modern Talking Pictures Service, Inc., 3 E. 54th St., New York 22, N. Y.

Name Changes

The name of General Electric's Trumbull Components Dept. has been changed to the Circuit Protective Devices Dept. The new name was selected as the most descriptive of the kinds of products that this General Electric component manufactures for low-voltage electrical distribution systems.

Horning-Cooper, Inc., Monrovia, Calif., has been renamed Cooper Development Corp. The company specializes in the development of rocket and missile systems.

Ozalid Streamliner 200

full-width whiteprinting for just **$995.00!**

AT LAST—*economical printmaking in full 42-inch widths!* Here's the brand-new Ozalid Streamliner 200. This compact, low-cost table-model whiteprinter gives you solid production capacity . . . turns out a print in seconds.

It's perfect for the small office—priced low for any budget. And it's an ideal "stand-by" for the big printroom. Use it when other equipment is out of service. Use it for short run "rush" work—without costly interruptions of volume printmaking.

With all of these "plus" features:

- full 42-inch printmaking capacity
- compact design—only 22" high . . . 27" deep
- simple, easy-to-operate controls
- automatic stacking
- sharp, fully detailed prints

For all the facts on the Streamliner 200, call your local Ozalid representative, or write: Ozalid, Dept. O-11, Johnson City, N. Y.

OZALID®

First name in whiteprinting

A Division of General Aniline & Film Corporation. In Canada: Hughes Owens Company, Ltd., Montreal

EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

Positions Vacant
Positions Wanted
Part Time Work

Civil Service Opportunities
Selling Opportunities Wanted
Selling Opportunities Offered

Employment Agencies
Employment Services
Labor Bureaus

DISPLAYED —**RATES**— **UNDISPLAYED**

The advertising rate is $27.40 per inch for all advertising appearing on other than a contract basis. Frequency rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—8 columns—30 inches to a page.

Subject to Agency Commission.

$1.80 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box Numbers—counts as 1 line.

Position Wanted ads are ½ of above rate.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

Send NEW ADS to Classified Advertising Div. of PRODUCT ENGINEERING, P. O. Box 12, N. Y. 36, N. Y., for Oct. Issue closing Sept. 19th

---

Engineers . . . Mechanical Design

YOU CAN LOOK AHEAD HERE and SEE ADVANCEMENT

. . . professionally and salary-wise.

Since 1953 the Small Aircraft Engine Department of General Electric has increased its staff phenomenally and for a very definite reason . . . the progress of the organization in developing outstanding products in a comparatively new field.

Most recent proof of this is the new T-58 turbo . . . which you've probably read about in newspapers and professional journals. This power plant is notable for a number of revolutionary advances, including the basic one of a power-weight ratio of more than 4 to 1.

Now a whole family of new small-sized but giant-powered turbo-jet, turbo-shaft and turboprop engines are being developed . . . AND YOU CAN HAVE A HAND IN THE PROGRAM . . . if you qualify through a knowledge of high speed machines and broad design experience in any of the following fields:

- **stress analysis**
- **experimental analysis of mechanics**
- **solid mechanics**
- **vibrations analysis**
- **mechanical analysis**

You'll be designing a variety of static and moving parts: compressors, combustors, lube systems, turbines, gear systems, control components.

And you'll have the advantages of General Electric's extensive benefits, plus the cultural, educational and recreational facilities of Boston and vicinity.

Write in complete confidence to:

Mr. T. S. Woerz (Section R-A-1(2))

Small Aircraft Engine Dept.

GENERAL ELECTRIC

1000 Western Avenue, West Lynn, Mass.

ENGINEER

LAMSON CORPORATION

BILLMYRE BLOWER DIVISION

Application and Design Engineering in Medium Pressure Blowers, Central Vacuum Cleaning and Industrial Exhaust Systems. Small dynamic division expanding rapidly offers exceptionally interesting challenging opportunity to a man with capabilities in this specialized field. Contemplated product redesign, market expansion in immediate prospect.

For further information and interview, write

Director of Personnel
Lamson Corporation
Syracuse 1, New York

Scientists And Engineers For Acoustic Research

The expanding and diversified work of our Acoustics Group offers unusual opportunities for versatile and imaginative research scientists. Positions are available for experienced personnel, as well as recent Electrical Engineering, Mechanical Engineering or Physics graduates, in the following fields of applied acoustics:

ARCHITECTURAL ACOUSTICS — INDUSTRIAL AREA QUIETING
ELECTROACOUSTICS — VIBRATION PROBLEMS
ULTRASONICS — PROPERTIES OF MATERIALS
MACHINERY NOISE REDUCTION — ACOUSTICAL CALIBRATION
SOUND PROPAGATION

Currently we have over 30 industrial and government projects in operation. Professional development is encouraged through publication of papers, participation in professional activities and our educational program providing tuition-free graduate study.

If you are interested in this excellent opportunity to advance professionally, besides receiving an excellent salary, write:

A. J. PANERAL

ARMOUR RESEARCH FOUNDATION

of Illinois Institute of Technology

10 West 35th St. Chicago 16, Illinois

ASSISTANT GENERAL MANAGER

$17000

Will be responsible for small experimental plant and medium sized but growing research department. Experience in Research and development with special machinery desirable. M.E. degree preferred but experience without will be considered.

JOHN BALKANY

6 N. Michigan Ave. Room 708 Chicago 2, Illinois

PRODUCT ENGRS. (3)

8,000 to 12,000 a year

Top grade progress mfg. seeks project level engrs. experienced in appliance, instruments or power tool research & development. These are perm., non-defense positions. All replies confidential. Prompt response. Contact:

J. J. COOPER Rm. 940

64 E. Jackson Blvd., Chicago, Ill., WA 2-1918

LEGAL NOTICE

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDMED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION

Of Product Engineering published monthly with add'l issue in mid-October, at Albany, N. Y., for October 1, 1956.

1. The name and address of the publisher, editor managing editor and business manager is: Publisher, McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York 36, N. Y.; Editor, George F. Nordenholt, 330 West 42nd Street, New York 36, N. Y.; Managing editor, Robert W. Carson, 330 West 42nd Street, New York 36, N. Y.; Business manager, R. T. Douglas, 330 West 42nd Street, New York 36, N. Y.

2. The owner is McGraw-Hill Publishing Company, Inc., 330 West 42nd St., New York 36, N. Y. Stockholders holding 1% or more of stock are: Donald C. McGraw and Willard T. Chevalier, Trustees under Deed of Trust dtd. 1/14/21, as amended, m/b James H. McGraw, deceased; Donald C. McGraw and Harold W. McGraw as Trustees under Indenture m/b James H. McGraw, dated 7/1/37, as amended; Donald C. McGraw, individually; Harold W. McGraw, individually; Elizabeth M. Webster, c/o Donald C. McGraw (all of 330 West 42nd St., New York 36, N. Y.); Mildred W. McGraw, Madison, New Jersey; Grace W. Mehren, 536 Arenas St., La Jolla, Calif.; Genoy & Co., P. O. Box 491, Church St. Station, New York, N. Y.; Merrill, Lynch, Pierce, Fenner & Beane, 70 Pine St., New York, N. Y.; Touchstone & Co., c/o Wellington Fund, Inc., Claymont, Delaware.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: None.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

McGRAW-HILL PUBLISHING COMPANY, INC.
By JOHN J. COOKE, Secretary.

Sworn to and subscribed before me this 14th day of September, 1956.

[SEAL] JANET A. HARTWICK.
(My Commission expires March 30, 1957)

SYLVANIA'S ELECTRONIC DEFENSE LABORATORY

(on the San Francisco Peninsula)

needs

MECHANICAL ENGINEERS

for research and development in electronic warfare.

The Laboratory is engaged in creative work in a variety of fields.

Specialized experience in military design or electromagnetic fields is desirable but not required. It is more important that candidates be engineers with initiative and imagination.

Liberal benefit program including part time off with pay for advanced study at nearby universities and reimbursement for one-half the cost of tuition.

Outstanding insurance, retirement and medical programs.

Our laboratory is located five miles from Stanford University, close to excellent schools and in an ideal climate.

RELOCATION EXPENSES PAID

Please send complete resume to:
J. C. Richards

ELECTRONIC DEFENSE LABORATORY
P O BOX 205
Mountain View, California

DESIGN ENGINEERS

Our needs are due to the fact that our business has doubled in the last five years. Here is an excellent opportunity to get into the dynamic field of data processing equipment and office automation. As a result of continual expansion, permanent positions are available for designers in these areas: Small mechanisms, electromechanical devices, and machine design.

MECHANICAL ENGINEER

A graduate mechanical engineer is needed to handle a program of systematic investigation and testing of new business machine devices and auxiliary products; involves some technical report writing.

RECENT GRADUATES

Are you dissatisfied with your position since graduation? A medium-sized company such as Standard Register will give you the opportunity for growth and individual expression not permitted in your present situation.

These positions are with a well established, progressive manufacturer of business forms and mechanical and electronic devices related to business machines and integrated Data Processing. Excellent employee benefits and advancement opportunities. Replies kept confidential. Write to:

Professional Employment
THE STANDARD REGISTER COMPANY
Dayton 1, Ohio

NO PHYSICISTS, ENGINEERS NEEDED (Back in 1895, that is)

A short 61 years ago, there were those who claimed that the great work had all been done . . . that no new discoveries of major importance were likely to be made in the future. At that very time, however, Professor Wilhelm Roentgen had begun a series of experiments destined to reveal a force of nature that would revolutionize medicine and technology and become an instrument for deeper probing of the structure of matter—the X-Ray.

The 1895 cry certainly doesn't apply today! Farnsworth needs and wants qualified physicists and electronics engineers for research, development and production on ideas *even more revolutionary than Roentgen's:* Missile guidance, control and test equipment systems, microwaves, radar and countermeasures, infra-red systems, industrial electronics, antennas, transistor and pulse circuitry and packaging.

If you feel lost in a labyrinth of detail and routine . . . want a challenge as well as a change . . . you'll find

ENOUGH HERE TO CHALLENGE A HUNDRED ROENTGENS!

Farnsworth

A DIVISION OF IT&T

Address Technical Employment Director
FARNSWORTH ELECTRONICS COMPANY, FORT WAYNE, INDIANA
A Division of International Telephone and Telegraph Corporation

MECHANICAL ENGINEERS
Research and Development

Interesting positions open for mechanical engineers on a wide variety of projects in the following fields:

Experimental Stress Analysis — **Machine Design**
Mechanism Analysis — **Servomechanisms**

B.S. to Ph.D. in mechanical engineering with 3 to 5 years' experience in one of these fields essential. These are permanent positions offering an opportunity to use your initiative and creative ability. We offer excellent employee benefits including tuition-free graduate study.

For employment application, call CAlumet 5-9800, or write

Mr. J. A. Metzger
ARMOUR RESEARCH FOUNDATION
of Illinois Institute of Technology
10 West 35th Street Chicago, Illinois

DEVELOPMENT ENGINEER
RESEARCH

Northern Ohio Plant—Leading Concern in its Field—Experience Testing and Developing Automotive Brake Linings—Transmissions—Supervise Dynamometer Customer Contact, Etc.—Salary Open—Please Submit resume with Personal—Educational and Employment Backgrounds, including salary desired. Degree Required.

S. K. WELLMAN CO.
200 Egbert Rd. Bedford, Ohio

DESIGN ENGINEER

Well situated Central Connecticut Company which is in the process of growing from the classification of small to that of medium size has opening for a young engineering graduate with a minimum of two years of design experience preferably in the field of hydraulics. This man will receive directly from the Chief Engineer projects which are interesting and challenging and will give him a diversified knowledge of the company's rapidly expanding product line. Projects are primarily in the aircraft and atomic energy fields. Excellent working conditions and potential for personal progress as well as participation in company growth.

P-3271, Product Engineering
Classified Adv. Div.,
P. O. Box 12, New York 36, N. Y.

Mechanical Engineer—3M Company
Machine or Product Design

Outstanding opportunity for a Mechanical Engineer in a position with a future in one of America's top growth companies.

Experience in experimental or production machine design and development required.

Engineering degree preferred—industrial equivalent considered. Age and salary open.

***Write*—Technical Employment Manager**
MINNESOTA
MINING AND MANUFACTURING CO.
St. Paul 6, Minnesota

ELECTRICAL ENGINEERS
INSTRUMENTATION
TO $12,000 PER YEAR

For design, development of instruments and related circuitry which measures conditions such as temperature, fluid flow and pressure. Experience in such industries as oil refineries, public utilities (water, gas, electrical) would be entirely acceptable. Client assumes all expenses.

28 E. Jackson Blvd. Chicago 4, Ill.
MONARCH PERSONNEL

REPLIES (Box No.): Address to office nearest you
c/o This publication Classified Adv. Div.
NEW YORK: P. O. Box 12 (36)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

Wanted: Mechanical and Structural design engineers and draftsman for plant layout work and automatic equipment. Work involves board work and some field work. Experience in pulp or paper mill helpful but not essential. Location South. Good opportunity for desirable applicants. Give experience and salary range with application. P-2703, Product Engineering.

Wanted: Electrical Engineering draftsman for general plant power layout work also automatic control. Give experience and present salary range with application. Location South. P-2704, Product Engineering.

Refrigeration Engineer a progressive, mid-western manufacturing concern needs a refrigeration engineer with considerable experience and creative ability. Graduate engineer or equivalent. Minimum of 5 years experience in refrigeration design and application. Excellent opportunity for qualified man. P-3127, Product Engineering.

EMPLOYMENT SERVICE

Mechanical Engineer design 8 years experience in design of small mechanical devices such as instruments automotive parts 30-45 fee paid 10,000. Edwards Employment Agencies, Inc., Executives-Engineers 73 Warren St., New York 17, N. Y. Barcley 6-3672.

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Position open for either electronic or industrial engineer with some electronic experience for work in Standards Section. Previous manufacturing experience required. Must be familiar with parts numbering systems and standardization procedures. Wonderful opportunity in growing concern. Complete employee benefits. Enjoy the advantages of a small mid-west city.

Send complete details and photo to,

Personnel Director
GATES RADIO COMPANY
Quincy, Illinois

New "SEARCHLIGHT" Advertisments

received by 10:00 A.M. Nov. 16 will appear in the December issue, subject to space limitations.

Classified Advertising Division
PRODUCT ENGINEERING
330 W. 42nd St., New York 36, N. Y.

SEARCHLIGHT SECTION
(Classified Advertising)

BUSINESS OPPORTUNITIES
EQUIPMENT - USED or RESALE

DISPLAYED RATE

Individual Spaces with border rules for prominent display of advertisements.

The advertising rate is $18.85 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

UNDISPLAYED RATE

$1.80 a line, minimum 3 lines.

Box Numbers—Care of publication count as one line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Equipment Wanted or *For Sale* Advertisements acceptable only in Displayed Style.

ALUMILITED ALUMINUM
Flat & Embossed SHEETS

Die formed panels used for store fronts, signs, trailers, displays, dryers, etc. Anodized sheet supplied for all purposes.

LUSTRIK, Inc. Reg. T.M.
3235 Frankford Ave. Philadelphia 34, Pa.

Special Pre-Publication Offer
CIRCULAR SAW HANDBOOK
BAND SAW HANDBOOK
Edited by Henry C. Atkins
Former Supt. of H. C. Atkins Co.
Contains vital information for equipment mfgrs, sawmill operators, maintenance men, apprentices.
$5 per copy Order from
CHAIN SAW AGE Portland 66, Oregon

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ARNOLD E. RUDAHL
Electro-mechanical Product Engineering

- Magnetic devices, synchro, servo, control components, specific-performance motors, from appliance drives to automation instruments.
- Custom-designed, specification, technical procurement.

Co-ordinated development of component, system and equipment. Prototype and engineering quantity production.

527 East Putnam Ave. Greenwich, Conn. Tel.: 8-7995

Your Inquiries to Advertisers Will Have Special Value . . .

—for you—the advertiser—and the publisher, if you mention this publication. Advertisers value highly this evidence of the publication you read. Satisfied advertisers enable the publishers to secure more advertisers and—more advertisers mean more information on more products or better service—more value—to YOU.

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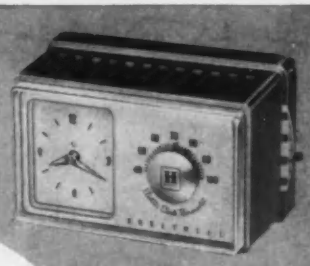
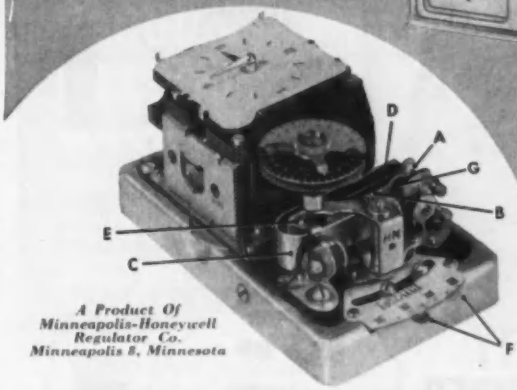
HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE NEW





A Product Of Minneapolis-Honeywell Regulator Co. Minneapolis 8, Minnesota

MINNEAPOLIS Honeywell Clock Thermostat

This newly designed Electric Clock Thermostat, No. T852A, gives 'round the clock comfort while it adds a touch of elegance to your home. It turns down the heat—automatically—when you go to bed and turns up the heat—automatically—while you're still asleep. Reduces fuel bills, too. The faithful heart of this precision instrument is, of course, Chace Thermostatic Bimetal.

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CASE HISTORY 1

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HASSALL SOLUTION:

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CASE HISTORY 36

REQUIRED:

Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:

Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.

CASE HISTORY 89

REQUIRED:

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HASSALL SOLUTION:

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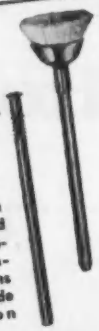

CASE HISTORY 37

REQUIRED:

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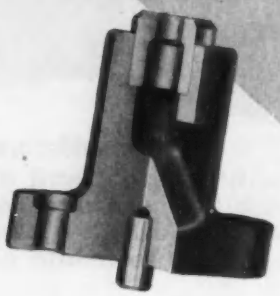

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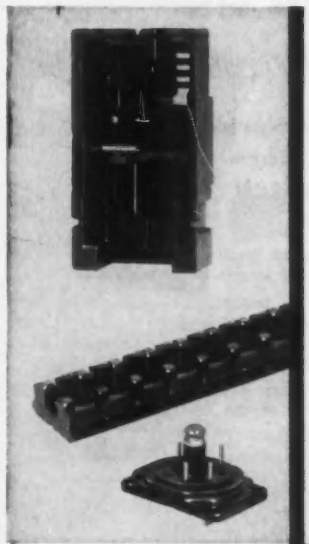

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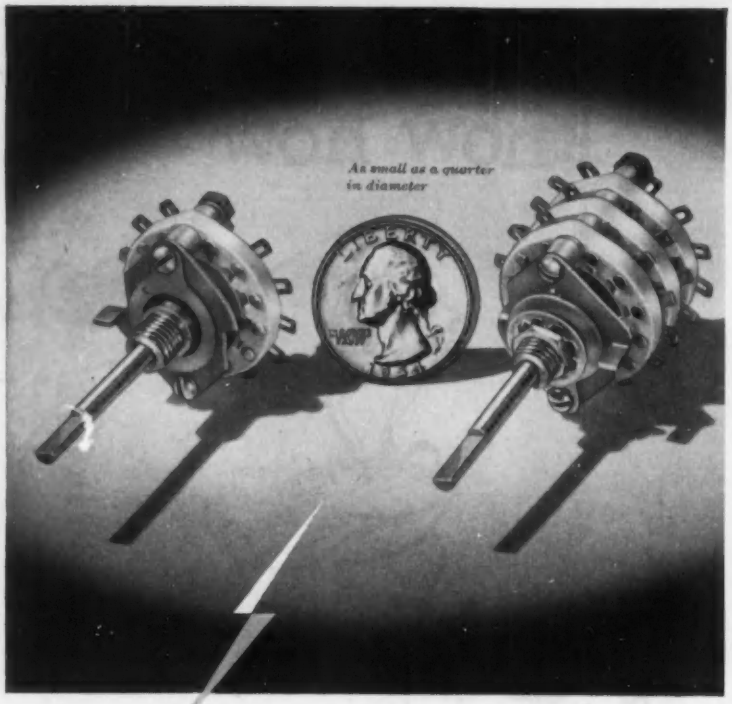

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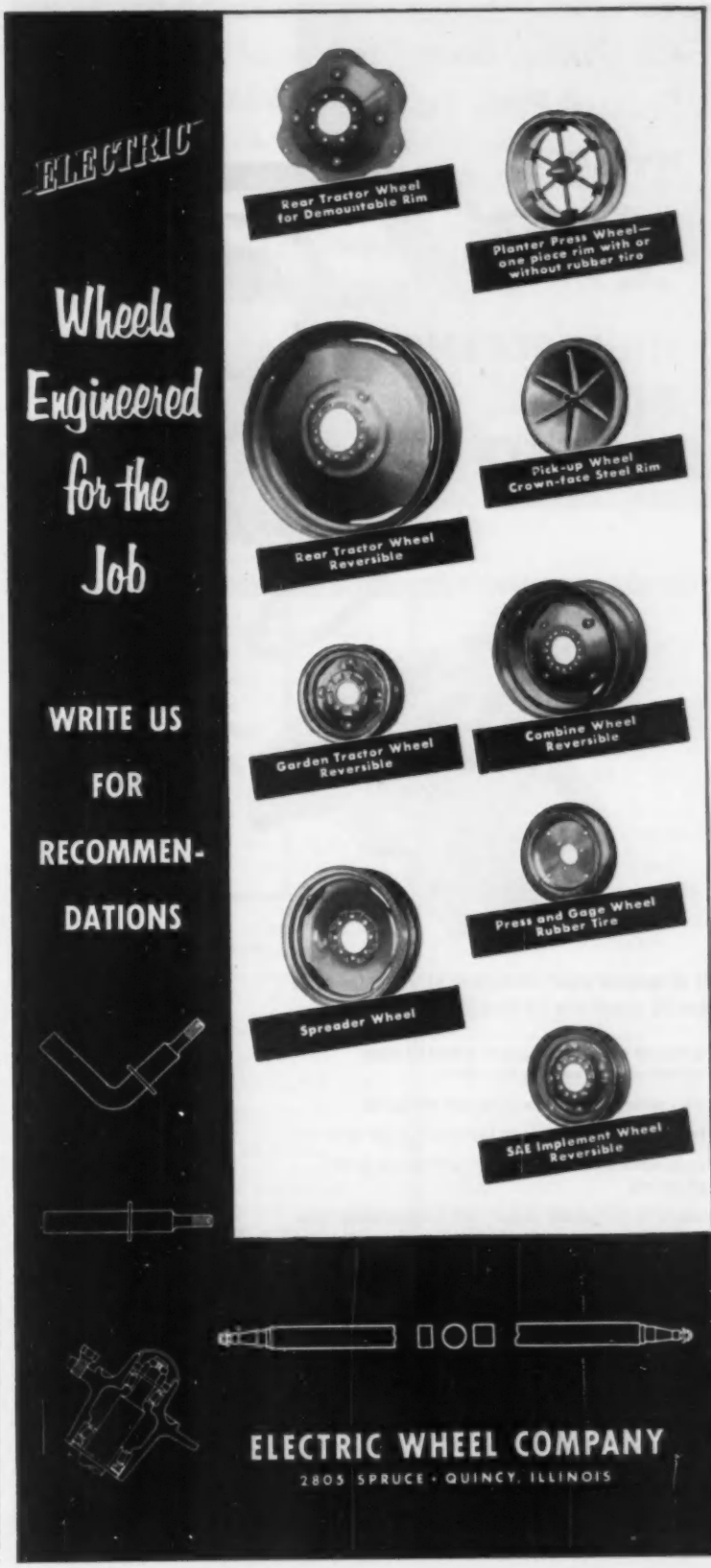
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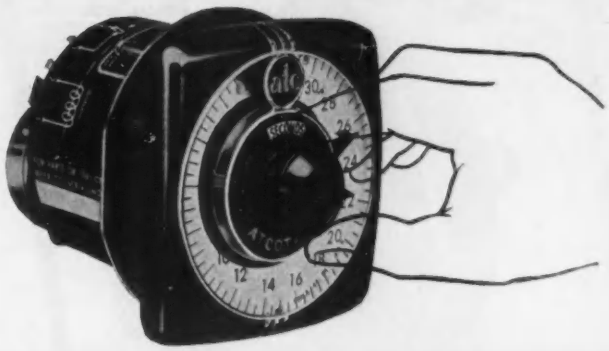
Why have orders for this unique miniature timer increased 496% in the last year?



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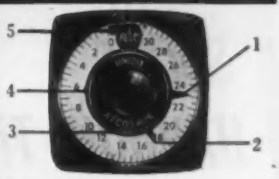
All terminals face the rear and are protected by an arc barrier to facilitate wiring and eliminate possibility of shorts. One piece terminal block is made of strong acrylic resin, fibre-glass reinforced.

Large, vertical silver contacts assure cleanliness and non-burning, low resistance conductance. Good contact wiping action.



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1) Total cycle time, 2) elapsed time, 3) motor operation, 4) clutch operation, 5) switch action.

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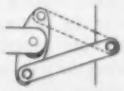
Unique, non-slip clutch with infinite engagement points eliminates gear teeth mesh. Long life, unaffected by wear.



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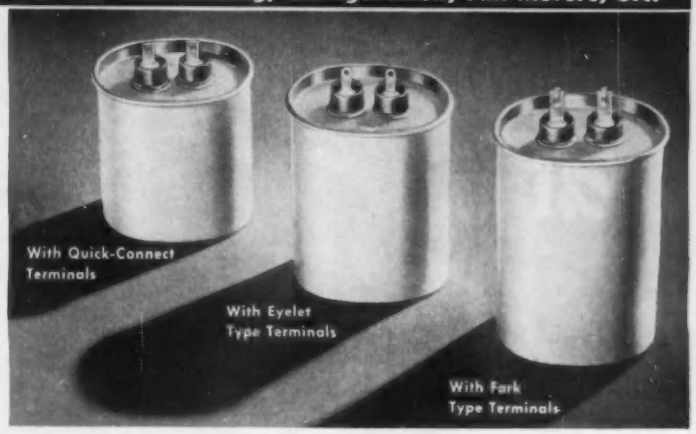
For Air Conditioning, Refrigeration, Fan Motors, etc.



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...save space, weight and cost!

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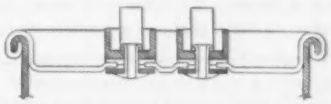

Three types of terminals, (see illustration) to fit your particular needs—speed connecting time whether you prefer mechanically joined or soldered leads.

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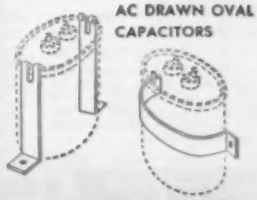

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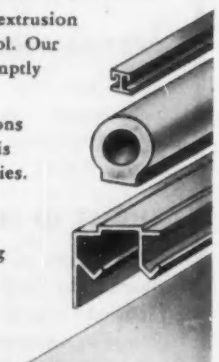

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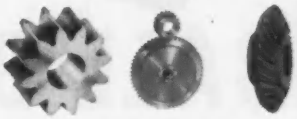

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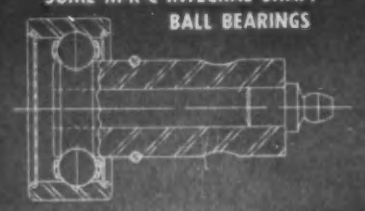
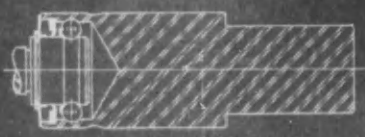
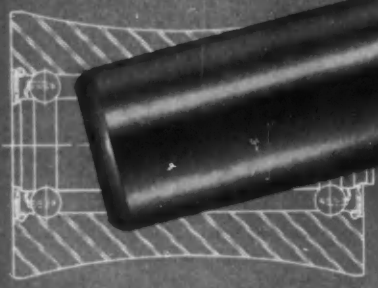
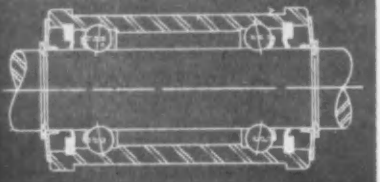
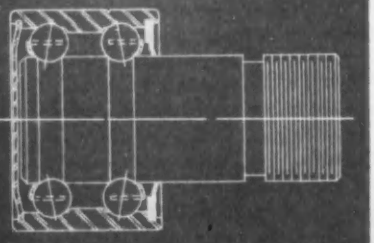
SOME M-R-C INTEGRAL SHAFT BALL BEARINGS

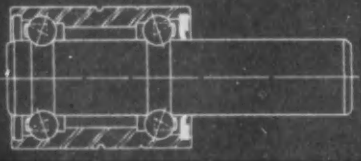












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NEW PRODUCTS...

Description of these new engineering materials appear on pages 226-338. Circle key number for more data

1—Plug-In Industrial Relays
2—Magnetic Memory System
3—Geneva Movements
4—Timing Pulse Generator
5—Liquid Pressure Pickup
6—Fasteners with Curved Tool Recess
7—Solders Contalning Indium
8—Vapor Pressure Temperature Regulator
9—Pressure Scanner
10—Thermostats Rated At 25 Amp
11—Miniature, Sealed Relay
12—Transparent Tape
13—Connectors with Filled Contacts
14—D-C Power Supply
15—Terminal for Aluminum Wire
16—Discharge Varistor Assembly
17—Self-Sticking Diagrams
18—Self-Locking Washer-Nut
19—Interval Timer
20—Flush-Mount, Locking Clinch Nuts
21—Fnp Motor with 2,592,000:1 Ratio
22—Miniature Differential
23—Treated Teflon Yarn
24—Switches for up to 24 hr Control
25—Motor-Driven Commutation Switch
26—Explosionproof Magnetic Brakes
27—Silicone Rubber Compounds
28—Manifold Mount Control Valves
29—Nylon Powder for Pressing
30—Photoelectric Control
31—Rotary Toggle Switch
32—Mounting Stud With Pilot
33—Demountable Plate Cylinders
34—Electro-Pneumatic Valve
35—Voltage Stabilizer
36—Light-Wall PVC Pipe
37—Copper-Clad Hardenable Steel
38—Sealed Bearing Caster
39—Double Solenoid Air Valve
40—Cylinders with Non-Rotating Rods
41—Sequence Timer-Recorder
42—Solenoid-Controlled Mixing Valve
43—Differenial Speed Reducer Pulley
44—PVC Expansion Joint
45—Constant Level Oiler
46—Thermal Relief Valve
47—Silicon Rectifier Stacks
48—Needle and Globe Valves of PVC
49—Swivel Coupling
50—Trimming Potentiometer
51—Switch Assemblies
52—Explosionproof Pressure Control
53—Ultra-Thin Metal Strip
54—Narrow Range Speed Control
55—Subminiature Pilot Lights
56—Nylon Pellet Locks Fastener
57—Packaged Industrial Controls
58—Safety Relief Valve
59—Vacuum Pressure Switch
60—Split-Contact Switch
61—Close-Tolerance Limit Switch
62—Polyurethane Foam Materials
63—High Sensitivity Relay
64—Finish for Die Castings
65—Aluminum Packing Gland
66—Absolute Air Pressure Switches

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CIRCLE THESE NUMBERS FOR INFORMATION ON NEW PRODUCTS LISTED IN THIS ISSUE

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USE THIS SPACE..... TO INDICATE REQUIRED.....

67—Self-Locking Cap Nuts
68—Compression-Type Pipe Coupling
69—Time Delay Relay
70—Large Nuts
71—Solder Preforms
72—Oil and Heat-Resistant Label
73—Device Cleans Mechanisms
74—Pushbutton Switch
75—Copper Dispersion
76—Expanded Polyethylene Foam
77—Traverse and Feed Controls
78—Plug Valve
79—Expanded Scale Voltmeters
80—Machine Tool Relay
81—Teflon Tape
82—Epoxy-base Paint
83—Tin-Clad Nickel Strip
84—Reversible Flip Motor
85—Counterbored Locking Fasteners
86—Fire-Resistant Hydraulic Fluid
87—Four-Pole, Flip Motor
88—Double Universal Joints
89—Three-Digit Voltmeter
90—Test Point Connector
91—Silver-Plated Copper Wire
92—Alloy for Investment Casting
93—Steel Clip for Clamp
94—Variable Voltage Transformer
95—General Purpose Time Switch
96—Nickel Cadmium Battery
97—Gas and Mercury-Vapor Thyratron
98—Thermostatic Traps
99—Hydraulic Accumulator
100—Plug-In Circuit Design Kit
101—Direct-Recording Oscillograph
102—Working Scale Models
103—Lead Holder
104—Molded Coil Kit

NEW BULLETINS . . . listed below are described on pages 341-352. Circle key number for your copy.

105—Zinc Coating, 4pp, Sealube Co.
106—Heavy Duty Series, 2 pp, Leech-Neville Co.
107—Lockwashers, 4 pp, Pioneer Stamped Products Co.
108—Hollow Aluminum Bar Stock, 8 pp, Harvey Aluminum
109—Pump Troubles, 4 pp, Worthington Corp.
110—Air and Water-Cooled Compressor Troubles, 4 pp, Worthington Corp.
111—Irradiated Polyethylene, 12 pp, General Electric Co.
112—Tubing System Data, 8 pp, Parker Appliance Co.
113—Conveyor Pulleys, 12 pp, R. & J. Dick Co., Inc.
114—Truck Casters and Wheels, 68 pp, Bond Foundry & Machine Co.
115—Power Transmission Machinery, 328 pp, Dodge Mfg.
116—Retaining Rings, 11 pp, Industrial Retaining Ring Co.
117—Repulsion-Induction Motors, 2 pp, Peerless Electric Co.
118—D-c Motors, 6 pp, Allis-Chalmers Mfg. Co.
119—Polyethylene Pipe, 8 pp, American Hard Rubber Co.
120—Constant Voltage D-c Power Supplies, 8 pp, Sola Electric Co.
121—Lithium Compounds, 38 pp, Foote Mineral Co.
122—Precision Balls, 4 pp, Universal Ball Co.
123—Thermistor Overheat Detectors, 3 pp, Fenwal Inc.
124—Dollar Savings through Standards, 40 pp, American Standards Assn., Inc.

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TR446	BR446	L447	R447	449	L450	TR450	BR450	451	452	453	L454	TR454	BR454	
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PRODUCTS ADVERTISED

NEW PRODUCTS . . .

NEW BULLETINS . . .

SPECIFIC DATA . . .

125—Systems for Automatic Lubricators, 12 pp, Bijur Lubricating Corp.

126—Potentiometers and Accelerometers, Bulletins (2), 2 pp, Humphrey Inc.

127—Contacts and Rivets, 4 pp, Deringer Metallurgical Corp.

128—Motors, 16 pp, General Electric Co.

129—Delivery Date Calculator, Nooter Corp.

130—Speed Reducers, 4 pp, Metron Instrument Co.

131—Automatic Clutches and Transmissions, 4 pp, Salsbury Corp.

132—Tool Steel Handbook, 204 pp, Allegheny Ludlum Steel Corp.

133—Time Controls, 20 pp, Paragon Electric Co.

134—Speed Reducers, 45 pp, Westinghouse Electric Corp.

135—Thermistor-Actuated Temperature Controller, 4 pp, Fenwal Inc.

136—Linear and Angular Micro-Positioning Systems, 12 pp, Farrand Controls, Inc.

137—Detachable Couplers, 15 pp, Foster Mfg. Co., Inc.

138—Straight Line Thrust Mechanisms, 8 pp, General Electric Co.

139—Miniature Electrical Connectors, 8 pp, Deutsch Co.

140—Precision Radial Roller Bearings, 58 pp, Rollway Bearing Co., Inc.

141—Bolts, Nuts, Screws, Rivets and Washers, 130 pp, Sterling Bolt Co.

142—Control and Data Processing, 31 pp, Consolidated Electrodynamics Corp.

143—Flexible Plastic Tubing, 28 pp, U. S. Stoneware Co.

144—Safety Devices for Steam and Hot Water, 8 pp, McDonnell & Miller, Inc.

145—Vane-Actuated Switch, 2 pp, Minneapolis-Honeywell Regulator Co.

146—Plastic Engineering Materials, 17 pp, E. I. DuPont De Nemours & Co., Inc.

147—Temperature Controls, 6 pp, Fenwal Inc.

148—Full Flow Valves, 4 pp, Coppus Engineering Corp.

149—Formulated Epoxy Resins, Chart, Furane Plastics Inc.

150—Forgings and Castings, 30 pp, Allegheny Ludlum Steel Corp.

151—Metals and Alloys for Tubing, 3 pp, Superior Tube Co.

152—Rotary Blowers, 5 pp, Miehle-Dexter Supercharger Co.

153—Pressure Tubing, 3 pp, Superior Tube Co.

154—Flow Controls, 8 pp, Fluid Controls Inc.

155—Wirerope, 188 pp, Macwhyte Co.

156—Plastic Tooling, 8 pp, Marblette Corp.

157—Silver-Cadmium Exide Electrical Contacts, 4 pp, H. A. Wilson Co.

158—Electric Welded Mechanical Steel Tubing, 3 pp, Walker Brothers, Inc.

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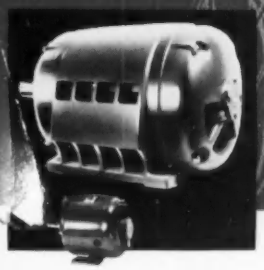
Why not build the cart before the horses?



Just tell us here at Master what you want in power drives—and get the utmost in flexibility, compactness and performance. It probably won't be as complicated as the multi-shaft Gearmotor illustrated here, with 14 shafts turning at diverse speeds. But, regardless of what you need, Master can supply the right combination of horsepower, shaft speed and mounting features with whatever Master components are required—all combined in one compact efficient unit. Just ask for information.

Motor Ratings. 1/8 to 400 H.P. All phases, voltages and frequencies.

Motor Types... Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.

Construction .. Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.

Speeds..... Single-speed, multi-speed, and variable speed.

Installation.... Horizontal or vertical, with or without flanges and other features.

Power Drive Features..... Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY, Dayton 1, Ohio

New! Completely redesigned milling machine switches spindle to TIMKEN® bearings

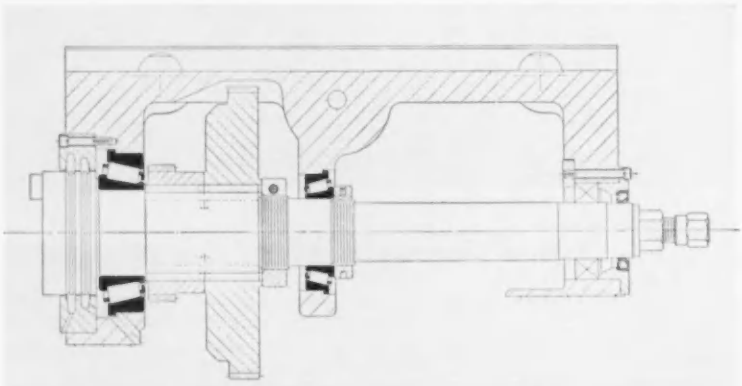
THIS Kempsmith Master-Mill, made by Kempsmith Machine Company, is a brand new, improved model—designed to meet new demands for higher production, lower milling costs. Kempsmith switched to Timken® tapered roller bearings on the new Kempsmith Master-Mill to offer users their many advantages on the spindle, on the table leadscrew, on elevating pinion, and cross feed screw.

Kempsmith reports that Timken bearings are easier to install and adjust, have greater load capacity in small space, are much easier to preload.

Timken bearings hold the spindle in rigid alignment, meeting the requirement of "zero end play over a 24 to 1500 rpm speed range." Tapered construction lets Timken bearings take the radial and thrust loads encountered by a milling machine spindle, in any combination.

Timken bearings were specified, too, because of the heavy shock loads induced by the milling cutter—shocks further amplified by interrupted cuts. Rollers and races in Timken bearings are case-carburized, with tough, shock-resistant cores under hard wear-resistant surfaces. They'll *take* heavy shock loads! And Timken bearings give extra load-carrying capacity with their full line contact between rollers and races.

Geometrically designed for true rolling motion, Timken bearings are precision-manufactured, under rigid quality controls, to conform to their design. We even make our own steel, something no other American bearing maker does. Buying or building machines like this? Look for the trade-mark "TIMKEN" on every bearing! The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".



KEMPSMITH MACHINE COMPANY mounts the spindle of their new Kempsmith Master-Mill milling machine on Timken tapered roller bearings to hold spindle in rigid alignment.

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD